The Society of the
Plastics Industry, Inc.

SPI

1987 edition

Facts & Figures of the U.S. Plastics Industry

SPI'S COMMITTEE ON RESIN STATISTICS

The Committee on Resin Statistics, only one of six service committees and 29 Operating Units within the Society of the Plastics Industry, is composed of 100 representatives from plastics resin producing companies, trade publications, industry-related professional organizations, and various agencies of the Federal Government. All members of the Committee are quite knowledgeable of the rapidly growing plastics industry and have a special interest in the development of marketing and economic data.

The Committee is responsible for the development and maintenance of a monthly report on the major plastics materials. This report shows monthly and cumulative data on production and sales & use (including captive operations) with percent change from the previous year. It is the only detailed monthly report on plastics materials now available. There are over one hundred producers participating in the monthly program and they are believed to represent about 95% of total U.S. plastics production. Many of the materials covered reflect 100% industry coverage. The data are compiled by Ernst & Whinney, nationally renowned Independent Public Accountants.

The Committee is actively involved with the various departments of the Federal Government (International Trade Commission, Department of Commerce, Bureau of the Census, Bureau of Labor Statistics, etc.) assisting them in the development and improvement of the plastics segments of their special reports.

The Committee is also responsible for monitoring all resin data which appear in FACTS & FIGURES, thus assuring the most accurate and timely data available in the plastics industry.

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Facts & Figures of the U.S. Plastics Industry

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THE SOCIETY OF THE PLASTICS INDUSTRY, INC.

The Society of the Plastics Industry, Inc. is a member-run federation dedicated to promoting and protecting continuing growth for the plastics industry in the United States. The Society represents more than 1,900 member companies responsible for over 95 percent of plastics materials production.

SPI's 29 operating units and more than 200 committees have membership drawn from all segments of the industry - processors, resin and adjuvant suppliers, plastics distributors, machinery builders, and moldmakers. The Society serves as a federation of semi-autonomous, interrelated groups with a strong, common interest in the overall health of the plastics industry.

SPI serves as the "industry spokesman." It identifies and provides positive responses to misinformation and to potentially harmful regulations, bills, or court decisions by mobilizing pertinent facts and carrying out programs for timely and forceful action. At the same time, SPI works to prevent such damaging situations from occuring by building a positive understanding of the industry. The Society's service committees provide liaison with government agencies, code and regulatory groups, and many other associations.

SPI sponsors research projects in areas such as resource recovery, combustibility, and worker safety, at major private research organizations. The Society conducts numerous information programs, providing literature, surveys, reports, newsletters, and handbooks for industry and public use.

SPI sponsors one of the largest trade shows in the United States - the National Plastics Exposition, held every three years. The next show will be in June 1988 at McCormick Place in Chicago.

Incorporated in 1937, SPI has grown with the dynamic industry it represents. In addition to the Society's headquarters office at 1275 K Street, N.W., Suite 400, Washington, D.C. 20005, SPI has four section offices: Eastern Office, 1275 K Street, N.W., Suite 400, Washington, D.C. 20005; Midwestern Office, 2400 East Devon Avenue, Suite 301, Des Plaines, IL 60018; New England Office, Stetson Place, 541 Main Street, Weymouth, MA 02190; Western Office, Saddleback Square, Suite 124, 12440 Firestone Boulevard, Norwalk, CA 90650; plus a New York Office, 355 Lexington Avenue, New York, NY 10017.

SPI draws together the diverse segments of the plastics industry into an effective organization that represents the entire industry.

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DEVELOPMENT OF TODAY'S PLASTICS

Today's plastics are one of the most used material on a volume basis in America's industrial and commercial life. The role of plastics is so broadly integrated in our own lifestyle that today there is virtually no product area where plastics do not make a major, irreplaceable contribution. Although the plastics industry in the United States is now in its second century, the most important developments have occurred since 1910. However, the roots of these modern developments go back not only to the research of cellulose nitrate by John Wesley Hyatt in the 1860's, but also to the plastic-like compositions used by man through the centuries.

ORIGIN OF PLASTICS

One can go as far back as the Old Testament to find references about natural materials used as fillers, adhesives, coatings, and the like. These materials were the precursors of what we call plastic materials today. Consequently, historians differ as to the exact date that the plastics industry began, and they will continue to do so since an exact year or even decade for the event is a matter of interpretation as to what constitutes a "plastic."

Certainly the history of the rubber industry has a bearing on plastics since ebonite, or hard rubber, discovered in 1851, was the first thermosetting material to be prepared and also the first material which involved a distinct chemical modification of a natural material. But ebonite was not exploited commercially for some years after its discovery and for that reason its historical importance has become somewhat blurred.

EUROPEAN DEVELOPMENTS

While the basic processes of rubber technology were developing, other important discoveries were taking place in Europe. Following work by Pelouze, Schonbein was able to establish conditions of controlled nitration of cellulose. The product soon became of interest as an explosive and in the manufacture of collodion, a cellulose solution in an alcohol-ether mixture. In the 1850's the English inventor Alexander Parkes observed that the solid residue left after the evaporation of the solvent of photographic collodion was a "hard, horny elastic and waterproof substance." In 1856 he patented the process of waterproofing woven fabrics by the use of such materials.

In 1862 the Great International Exhibition was held in London. It was there that Parkes introduced a new material named for himself—Parkesine. Parkesine was obtained by dissolving cellulose nitrate in a minimum of solvent. The mixture was then put on a heated rolling machine from which some of the solvent was then removed. While still in the plastic state the material was then shaped by dies or pressure. In 1866 Parkes organized the Parkesine Company to manufacture products from his new material, but the company failed in 1868. This appears in part due to Parkes' attempt to reduce production costs which resulted in the production of inferior items.

One year after the failure of the Parkesine Company, an associate of Parkes, Daniel Spill, formed the Xylonite Company to manufacture products similar to Parkesine. Once again economic failure resulted and Spill's company went bankrupt in 1874. Undaunted, Spill moved to a new site, established the Daniel Spill Company and continued production of his material, Xylonite.

FIRST PLASTICS IN THE U.S.

In the United States during the 1860's someone else was experimenting with cellulose nitrate—John Wesley Hyatt. In 1865 Hyatt became involved in devising a method for producing billiard balls from materials other than ivory. Originally using mixtures of cloth, ivory dust and shellac, in 1869 he patented the use of collodion for coating billiard balls. The patent came one year after his collodion material was introduced commercially.

John W. Hyatt and his brother Isaiah took out U.S. Patent 105,338 in 1870 for a process of producing a horn-like material using cellulose nitrate and camphor. Although Parkes and Spill had mentioned camphor in their work it was the Hyatt brothers who recognized the value of camphor as a plasticizer for cellulose nitrate. In 1872 the term celluloid was coined by Isaiah Hyatt to describe the Hyatts' commercially successful product.

The validity of Hyatts' patents was challenged by Spill and a number of court actions took place between 1877 and 1884. In the final action it was found that Spill had no claim on the Hyatt brothers, the judge ruling that the true inventor of the process was Parkes since he (Parkes) had mentioned the use of camphor in his patents. Thus, there was no restriction on the use of these processes and any company, including the Hyatts' Celluloid Manufacturing Company, were free to use them. After that decision the Celluloid Manufacturing Company prospered, changed its name to the American Celluloid Chemical Corporation, and eventually was absorbed by the Celanese Corporation.

FORMALDEHYDE RESINS

Next to cellulose nitrate the most important material in the early history of plastics was formaldehyde. Around 1897 there was a demand in German schools for a white chalkboard. Efforts to obtain such a product resulted in the discovery of casein plastics, produced by reacting casein (milk protein) with formaldehyde. The material soon became established under the trade names of Galalith and Erinoid, and today casein is still used by the button industry.

In 1899 Arthur Smith took out British Patent 16,274, the first dealing with phenol-formaldehyde resins, in this case for use as an ebonite substitute in electrical insulation. During the next decade the phenol-formaldehyde reaction was investigated mainly for academic interest. In 1907 however, Leo Hendrik Baekeland discovered techniques of so controlling and modifying the reaction that useful products could be made from it. Thus phenolics were the first fully synthetic resins to become commercially successful.

Prompted by the success of phenolic moldings, research began on reacting other materials, such as urea and thiourea, with formaldehyde. These materials were used in the manufacture of molding powders. Unlike the phenolics, they could be molded into light-colored articles and they rapidly achieved commercial success. Today these urea-based resins are used for molding powders, adhesives, and textile and paper finishing while the related melamine-formaldehyde resins are used in decorative laminates.

GROWTH OF MODERN PLASTICS

Cellulose acetate, a thermoplastic, was developed about the same time as the urea-based resins. Similar in structure to cellulose nitrate, it was found to be safer in processing and use. Cellulose acetate was introduced as a molding compound in 1927.

The period 1930-1940 saw the initial commercial development of today's major thermoplastics; polyvinyl chloride; low density polyethylene; polystyrene; and polymethyl methacrylate. The advent of the Second World War in 1939 brought plastics into great demand, largely as substitutes for materials in short supply, such as natural rubber. In the United States the crash program leading to large-scale production of synthetic rubbers resulted in extensive research into the chemistry of polymer formation, and eventually, to the development of more plastic materials.

The first decade after World War II saw the development of high density polyethylene and polypropylene and the growth of the newer plastics in many applications. Large-scale production of these materials reduced their cost dramatically. The new materials began to compete with the older plastics and even with the more traditional materials such as wood, paper, metal, glass and leather. Since that time the demand for plastics has increased steadily so that plastics are now accepted by designers and engineers as basic materials along with the more traditional materials. The automotive industry, for instance, relies on plastics to reduce weight and thus increase mileage.

INTRODUCTION OF PLASTICS RESINS

DATE	MATERIAL	EXAMPLE
1868	Cellulose Nitrate	Eye Glass Frames
1909	Phenol-Formaldehyde	Telephone Handset
1919	Casein	Knitting Needles
1926	Alkyd	Electrical Bases
1927	Cellulose Acetate	Tooth Brushes
1927	Polyvinyl Chloride	Wall Covering
1929	Urea-Formaldehyde	Lighting Fixtures
1935	Ethyl Cellulose	Flashlight Cases
1936	Acrylic	Brush Backs
1936	Polyvinyl Acetate	Flash Bulb Lining
1938	Cellulose Acetate Butyrate	Packaging
1938	Polystyrene	Housewares
1939	Nylon	Gears
1939	Polyvinylidene Chloride	Packaging Film
1939	Melamine-Formaldehyde	Tableware
1942	Unsaturated Polyester	Boat Hulls
1942	Low Density Polyethylene	Packaging
1943	Fluoropolymers	Industrial Gaskets
1943	Silicone	Motor Insulation
1945	Cellulose Propionate	Pens and Pencils
1947	Epoxy	Tools and Jigs
1948	Acrylonitrile-Butadiene-Styrene (ABS)	Luggage
1954	Styrene-Acrylonitrile (SAN)	Housewares
1954	Polyurethane	Foam Cushions
1956	Acetal	Automotive Parts
1957	High Density Polyethylene	Milk Bottles
1957	Polypropylene	Safety Helmets
1957	Polycarbonate	Appliance Parts
1959	Chlorinated Polyether	Valves and Fittings
1962	Phenoxy	Bottles
1964	Ionomer	Skin Packaging
1964	Polyphenylene Oxide	Battery Cases
1964	Polyimide	Bearings
1964	Ethylene-Vinyl Acetate	Adhesives and Coatings
1965	Polysulfone	Electrical/Electronic Parts
1970	Thermoplastic Polyester	Electrical/Electronic Parts
1973	Polybutylene	Piping
1973	Polyphenylene Sulfide	Telecommunications
1974	Polyethersulfone	Printed Circuit Boards
1975	Nitrile Barrier Resins	Non-food Packaging
1978	Linear Low Density Polyethylene	Extruded Film
1982	Polyetherimide	Electrical/Electronic Parts
1983	Polyetheretherketone	Wire and Cable
1984	Aromatic Copolyester	Electrical/Electronic Parts
1985	Liquid Crystal Polymers	Electrical/Electronic Parts

1986 IN REVIEW—PRODUCTION AND SALES & CAPTIVE USE*

(in millions of pounds)

RESIN	PRODUCTION			SALES & CAPTIVE USE		
	1986	1985	%CHANGE	1986	1985	%CHANGE
Epoxy	398	385	3.4%	375	367	2.2%
Phenolic	2,735	2,621	4.3	2,771	2,640	5.0
Polyester	1,271	1,223	3.9	1,265	1,233	2.6
Urea	1,271	1,210	5.0	1,266	1,203	5.2
Melamine	173	192	- 9.9	191	194	- 1.5
Total Selected Thermosets	5,848	5,631	3.9	5,868	5,637	4.1
ABS	1,092	1,028	6.2	1,080	1,016	6.3
SAN	92	87	5.7	87	84	3.6
HDPE	7,182	6,671	7.7	7,028	6,651	5.7
LDPE	8,903	8,889	0.2	8,799	8,790	0.1
Nylon	465	399	16.5	443	403	9.9
Polypropylene	5,812	5,139	13.1	5,824	5,275	10.4
Polystyrene	4,470	4,054	10.3	4,463	4,108	8.6
PVC	7,256	6,772	7.1	7,412	6,720	10.3
Thermoplastic Polyester	1,175	965	21.8	1,160	956	21.3
Total Selected Thermoplastics	36,447	34,004	7.2	36,296	34,003	6.7
Total Selected Plastics	42,295	39,635	6.7	42,164	39,640	6.4
All Other Plastics**	6,221	6,231	- 0.2	5,955	5,700	4.5
Grand Total	48,516	45,866	5.8%	48,119	45,340	6.1%

** Includes SPI Estimates

* Excludes Polyurethane

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

1986 IN REVIEW* — DISTRIBUTION OF SALES & CAPTIVE USE BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1986	1985	% CHANGE	SHARE OF TOTAL	
				1986	1985
Transportation	1,988	1,989	-0.1%	4.4%	4.4%
Packaging	13,267	12,774	3.9	29.5	28.2
Building/Construction	10,085	10,038	0.5	22.4	22.1
Electrical/Electronic	2,609	2,659	-1.9	5.8	5.9
Furniture/Furnishings	2,191	2,107	4.0	4.9	4.7
Consumer/Institutional	4,123	3,975	3.7	9.2	8.8
Industrial/Machinery	361	364	-0.8	0.8	0.8
Adhesives, Inks & Coatings	1,638	2,142	-23.5	3.6	4.7
Other	4,555	5,122	-11.1	10.1	11.2
Exports	4,206	4,170	0.9	9.3	9.2
Total	45,023	45,340	-0.7%	100.0%	100.0%

*Excludes Polyurethane

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TOTAL U.S. PRODUCTION AND SALES & CAPTIVE USE OF PLASTICS RESIN; 1960-1986

(in millions of pounds)

YEAR	PRODUCTION (Including Polyurethane)	SALES & CAPTIVE USE (Including Polyurethane)
[a]1960	6,321	5,363
1961	6,930	6,040
1962	8,197	7,150
[b]1963	9,364	7,632
1964	10,525	8,847
1965	12,219	11,035
1966	14,199	11,726
1967	14,473	12,284
1968	17,231	15,396
1969	19,720	16,495
1970	20,056	17,494
[c]1971	21,161	19,813
1972	26,475	25,504
1973	29,213	28,719
1974	29,274	27,890
1975	22,828	22,278
1976	29,196	28,379
1977	33,948	32,771
1978	37,605	36,818
1979	41,577	40,607
1980	37,347	36,896
1981	39,867	38,801
1982	36,607	36,639
1983	42,777	42,212
1984	46,336	45,221
1985	47,946	47,470
[d]1986	50,849	50,452

[a]U.S. Tariff Commission data used for 1960-1970. May exclude some captive use.
[b]Cellulosics not included through 1962. Included beginning in 1963.
[c]SPI data used for 1971-1986
[d]1986 includes SPI Estimates

Compound Growth Rate

Years	Total Production	Sales & Captive Use
1960-1985	8.4%	9.1%
1970-1985	6.0%	6.9%
1975-1985	7.7%	7.9%
1980-1985	5.1%	5.2%
1985-1986	6.1%	6.3%

TOTAL U.S. PLASTICS PRODUCTION AND SALES & CAPTIVE USE BY RESIN

(in millions of pounds)

	1977		1978		1979		1980		1981	
RESIN	**P**	**S & CU**	**P**	**S & CU**	**P**	**S & CU**	**P**	**S & CU**	**P**	**S & CU**
Epoxy	261	278	299	316	361	332	315	319	336	332
Phenolic	1,458	1,400	1,617	1,543	1,781	1,732	1,499	1,517	2,333	2,375
Polyester	1,061	1,045	1,209	1,199	1,147	1,152	947	949	997	977
Urea	963	951	1,122	1,103	1,367	1,355	1,165	1,147	1,165	1,139
Melamine	200	203	202	196	200	192	167	166	179	175
Total Selected Thermosets	3,943	3,877	4,449	4,357	4,856	4,763	4,093	4,098	5,010	4,998
ABS	1,069	1,057	1,134	1,118	1,191	1,183	920	916	916	900
SAN	115	113	120	121	124	126	111	103	107	105
HDPE	3,652	3,557	4,201	4,165	5,010	4,893	4,405	4,394	4,695	4,683
LDPE	6,471	6,488	7,111	7,147	7,793	7,815	7,291	7,467	7,693	7,516
Nylon	254	250	275	278	327	315	274	271	312	288
Polypropylene	2,747	2,698	3,074	3,055	3,841	3,894	3,648	3,714	3,955	3,888
Polystyrene	3,446	3,557	3,823	3,870	4,005	3,997	3,521	3,518	3,621	3,604
PVC	5,253	5,232	5,723	5,810	6,119	6,138	5,470	5,407	5,707	5,601
Thermoplastic Polyester	—	—	—	—	—	—	503	511	610	581
Total Selected Thermoplastics	23,007	22,952	25,461	25,564	28,410	28,361	26,143	26,301	27,616	27,166
Total Selected Plastics	26,950	26,829	29,910	29,921	33,266	33,124	30,236	30,399	32,626	32,164
All Other Plastics*	6,998	5,942	7,695	6,897	8,311	7,483	7,111	6,497	7,241	6,637
Grand Total	33,948	32,771	37,605	36,818	41,577	40,607	37,347	36,896	39,867	38,801

P=Production S & CU=Sales & Captive Use

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

*1986 Includes SPI Estimates

TOTAL U.S. PLASTICS PRODUCTION AND SALES & CAPTIVE USE BY RESIN (Cont'd)

(in millions of pounds)

1982		1983		1984		1985		1986		Compound Growth Rate 1976-1986
P	S & CU	P	S & CU	P	S & CU	P	S & CU	P	S & CU	S & CU
286	301	334	331	406	379	385	367	398	375	4.2%
2,006	2,060	2,484	2,529	2,502	2,510	2,621	2,640	2,735	2,771	**
865	851	1,084	1,072	1,232	1,231	1,223	1,233	1,271	1,265	2.7
998	976	1,172	1,167	1,199	1,189	1,210	1,203	1,271	1,266	4.5
158	155	180	181	210	197	192	194	173	191	0.4
4,313	4,343	5,254	5,280	5,549	5,506	5,631	5,637	5,848	5,868	**
740	737	NA	NA	1,128	1,098	1,028	1,016	1,092	1,080	1.5
91	85	93	91	99	88	87	84	92	87	-1.7
4,928	5,024	5,691	5,707	6,085	5,949	6,671	6,651	7,182	7,028	8.4
7,503	7,687	8,041	8,045	8,413	8,416	8,889	8,790	8,903	8,799	4.3
228	247	321	329	396	389	399	403	465	443	7.2
3,477	3,623	4,434	4,464	4,940	4,816	5,139	5,275	5,812	5,824	8.7
3,191	3,200	3,567	3,606	3,838	3,836	4,054	4,108	4,470	4,463	3.5
5,326	5,455	6,066	6,152	6,760	6,798	6,772	6,720	7,256	7,412	4.8
648	619	778	783	899	859	965	956	1,175	1,160	NA
26,132	26,677	28,991	29,177	32,558	32,249	34,004	34,003	36,447	36,296	5.9
30,445	31,020	34,245	34,457	38,107	37,755	39,635	39,640	42,295	42,164	5.8
6,162	5,619	8,532	7,755	8,229	7,466	8,311	7,830	8,554	8,288	6.5
36,607	36,639	42,777	42,212	46,336	45,221	47,946	47,470	50,849	50,452	6.0%

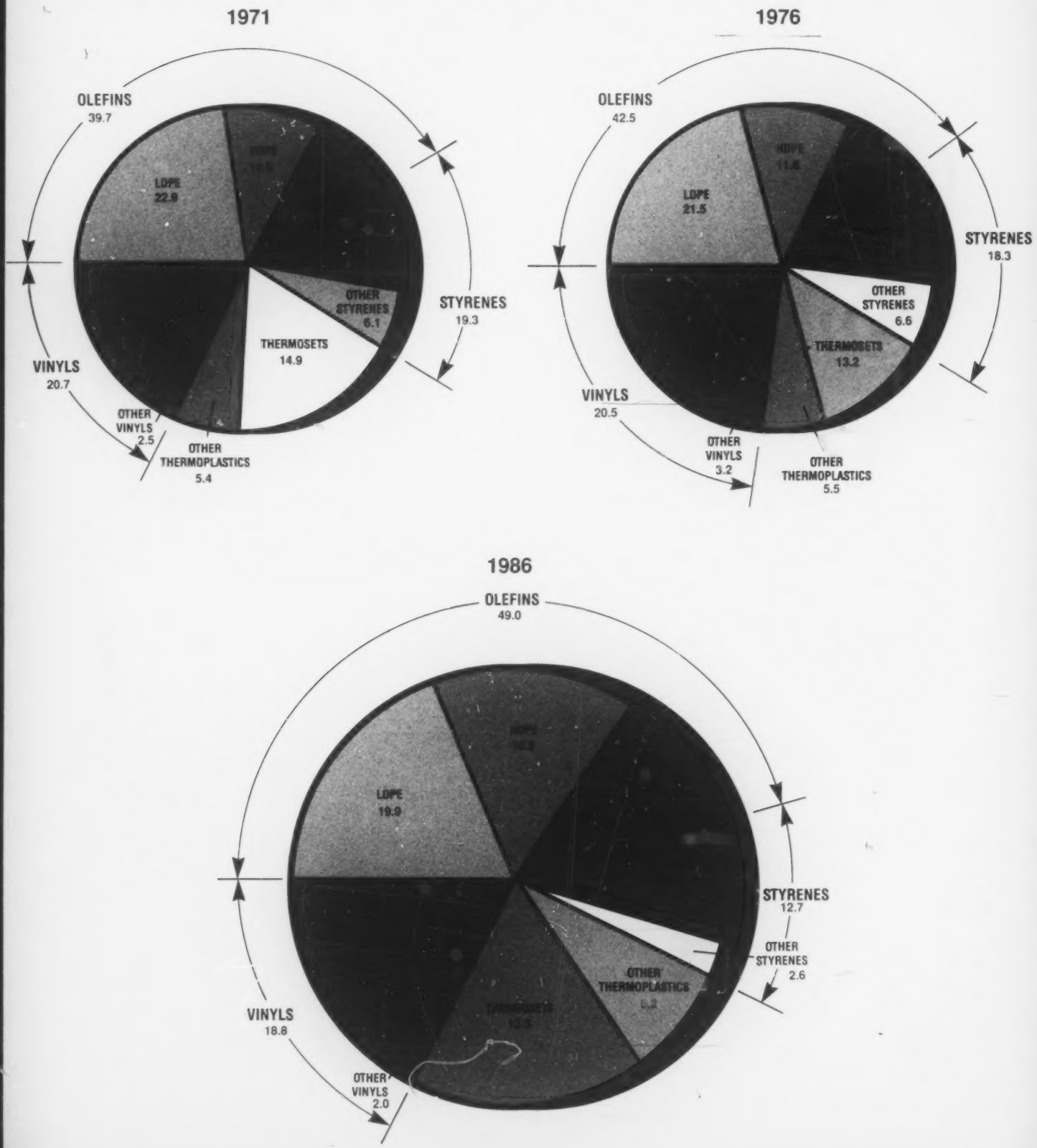
P=Production S & CU=Sales & Captive Use NA = Not Available

**Not applicable since reporting on gross weight basis begun in 1981

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

*1986 Includes SPI Estimates

PERCENTAGE DISTRIBUTION OF PLASTIC SALES & CAPTIVE USE BY MATERIAL



PLASTICS RESINS DOMESTIC MERCHANT SALES

(in millions of dollars and millions of pounds)

RESIN	1986		1985		% CHANGE	
	Net Dollar Value	Quantity	Net Dollar Value	Quantity	Net Dollar Value	Quantity
Low Density Polyethylene	$ 2,131	7,526	$ 2,087	6,809	2.1%	10.5%
Polyvinyl Chloride	1,740	6,323	1,543	6,055	12.8	4.4
High Density Polyethylene	1,636	6,102	1,540	5,516	6.2	10.6
Polystyrene	1,436	4,136	1,255	3,561	14.4	16.1
Polypropylene	1,290	3,886	1,197	3,406	7.8	14.1
ABS	690	951	743	913	-7.1	4.2
Other Styrenes	644	1,078	685	978	-6.0	10.2
Unsaturated Polyester	644	1,185	665	1,186	-3.2	-0.1
Thermoplastic Polyester	689	1,021	622	823	10.8	24.1
Nylon	545	368	541	356	0.7	3.4
Phenolic	409	1,992	502	2,346	-18.5	-15.1
Epoxy	362	305	415	307	-12.8	-0.7
Other Vinyls	172	104	251	208	-31.5	-50.0
Urea	178	1,123	188	1,063	-5.3	5.6
Melamine	134	153	139	162	-3.6	-5.6
SAN	41	64	48	71	-14.6	-9.8
Engineering Resins	1,015	580	NA	NA	-	-
All Other (excluding PVAC&PU)	NA	NA	4,212	3,377	-	-
Total	$13,756	36,897	$16,633	37,137	-17.3%	-1.0%

Domestic merchant sales are quantities of sales excluding interplant transfers, captive consumption and exports.

Net dollar value represents the actual selling price after deductions for cash discounts, quantity discounts, returned goods and allowances, federal excise taxes, local taxes, and outgoing transportation (prepaid or otherwise) to warehouses or customers.

NA = Not Available

Source: SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

APPARENT U.S. CONSUMPTION OF SELECTED PLASTICS RESINS

Apparent consumption is calculated by adding imports to production then subtracting exports. It is an accurate measure of the quantity of material actually consumed in the United States.

For purposes of the table below, the production figures were taken from SPI's Monthly Statistical Report, as compiled by Ernst & Whinney. Both the import and export figures were taken from Bureau of the Census reports.

1986
(in millions of pounds)

RESIN	PRODUCTION	IMPORTS	EXPORTS	APPARENT CONSUMPTION	IMPORT % OF APPARENT CONSUMPTION
Low Density Polyethylene	8,903	715	859	8,759	8
Polyvinyl Chloride	7,256	201	339	7,118	3
High Density Polyethylene	7,182	45	837	6,390	1
Polypropylene	5,812	25	1,173	4,664	1
Polystyrene	4,470	17	104	4,383	0
Phenolic	2,735	41	37	2,739	2
Styrene Copolymers (inc. ABS)	1,092	68	109	1,051	6
Urea	1,271	26	4	1,293	2
Unsaturated Polyester	1,271	7	39	1,239	1
Thermoplastic Polyester[a]	1,175	25	126	1,074	2
Nylon	465	31	67	429	7
Epoxy	398	17	97	318	5
Melamine	174	2	10	166	1
Other Vinyls	195	35	49	181	19
Total of these resins	42,399	1,255	3,850	39,804	3
1985 Total	40,836	1,205	3,552	38,489	3
1984 Total	39,293	899	3,484	36,708	2
1983 Total	37,145	581	3,767	33,959	2
1982 Total	31,262	268	4,102	27,428	1
1981 Total	33,696	307	3,596	30,407	1
1980 Total	31,247	247	4,194	27,300	1
1979 Total	34,550	273	3,625	31,198	1
1978 Total	31,101	234	2,302	29,033	1
1977 Total	28,077	136	1,978	26,235	1

[a]Not included in total 1977–1979

Source: Production—SPI Monthly Statistical Report, as compiled by Ernst & Whinney
Imports—Bureau of the Census, IM 146
Exports—Bureau of the Census, EM 546

PLASTICS MATERIALS & RESINS
VALUE OF SHIPMENTS
(in millions of dollars)

VERSUS LARGEST CHEMICAL CATEGORIES	1982	1983	1984	1985	1986	COMPOUND GROWTH RATE 1981-1986
Industrial Organic Chemicals	30,400	33,250	36,950	38,900	37,260	-0.6%
Drugs	24,700	27,400	29,950	32,500	33,430	8.5%
Plastics Materials & Resins	**15,800**	**18,900**	**20,800**	**21,600**	**22,000**	**5.7%**
Industrial Inorganic Chemicals	15,700	16,000	17,500	18,800	16,800	1.1%
Toilet Preparations	10,200	10,900	11,500	12,800	12,930	8.2%
Paints and Allied Products	9,150	10,200	11,700	12,600	11,100	0.1%
Soaps & Detergents	9,150	9,100	9,550	10,000	10,160	0.1%
Cyclic Crudes & Intermediates	7,100	7,400	8,200	8,400	8,085	0.2%
Fertilizers	7,300	6,900	8,000	8,100	5,520	-7.2%
Polishes & Sanitation Goods	4,600	4,700	5,100	5,300	5,230	2.0%
VERSUS OTHER COMMODITIES	**1982**	**1983**	**1984**	**1985**	**1986**	**COMPOUND GROWTH RATE 1981-1986**
Steel Mill Products	46,000	45,000	53,000	53,900	46,000	-7.8%
Paper and Board	30,900	32,800	39,000	38,000	41,600	5.4%
Cement and Concrete	16,700	18,000	20,600	22,350	23,000	5.0%
Plastics Materials & Resins	**15,800**	**18,900**	**20,800**	**21,600**	**22,000**	**5.7%**
Primary Aluminum	5,000	6,100	5,700	3,900	4,732	-6.2%
Synthetic Rubber	3,100	3,100	3,300	3,100	3,190	1.2%
Primary Copper	3,000	3,500	3,100	2,900	2,900	-11.9%
Leather Tanning & Finishing	1,800	1,900	2,000	1,700	1,647	-2.8%

Source: Department of Commerce estimates

PLASTICS MATERIALS & RESINS (SIC 2821)

(in millions of dollars except as noted)

	1983	1984[1]	1985[2]	1986[2]	PERCENT CHANGE 1983-84	1984-85	1985-86
Industry data							
Value of shipments[4]	18,936	20,830	21,562	21,954	10.0	3.5	1.8
Value of shipments (1982$)	18,568	19,413	20,189	21,524	4.6	4.0	6.6
Total employment (000)	53.2	56.3	53.9	53.0	5.8	-4.3	-1.7
Production workers (000)	32.7	34.1	34.1	33.3	4.2	0.0	-2.3
Average hourly earnings ($)	12.84	13.51	14.25	14.60	5.2	5.5	2.5
Product data							
Value of shipments[5]	21,053	22,913	23,830	24,000	8.8	4.0	0.7
Value of shipments (1982$)	20,539	21,146	22,209	23,365	3.0	5.0	5.2
Shipments price index (1982 = 100)[6]	102.5	108.4	107.3	NA	5.7	-1.0	NA
Trade data							
Value of imports (ITA)[7]	469	668	775	872	42.4	16.1	12.5
Import/new supply ratio[8]	0.022	0.028	0.032	0.035	27.3	14.3	9.4
Value of exports	2,510	2,655	2,546	2,747	5.8	-4.1	7.9
Export/shipment ratio	0.119	0.116	0.107	0.114	-2.5	-7.8	6.5

[1] Estimated except for exports and imports
[2] Estimated
[3] Forecast
[4] Value of all products and services sold by the Plastics Materials and Resins industry
[5] Value of products classified in the Plastics and Resins industry produced by all industries
[6] Developed by the Office of Industry Assessment, ITA
[7] Import data are developed by the chapter author
[8] New supply is the sum of product shipments plus imports
SOURCE: U.S. Department of Commerce: Bureau of the Census, Bureau of Economic Analysis, International Trade Administration, (ITA). Estimates and forecasts by ITA.
NA = Not Available

MISCELLANEOUS PLASTICS PRODUCTS (SIC 3079)

(in millions of dollars except as noted)

	1983	1984[1]	1985[2]	1986[2]	PERCENT CHANGE 1983-84	1984-85	1985-86
Industry data							
Value of shipments[4]	40,398	45,050	46,850	51,235	11.5	4.0	9.4
Value of shipments (1982$)	39,712	42,900	44,200	48,470	8.0	3.0	9.7
Total employment (000)	486	546	571	565	12.3	4.5	-1.1
Production workers (000)	376	426	442	450	13.3	3.7	1.8
Average hourly earnings ($)	7.16	7.47	7.76	8.00	4.3	3.9	3.1
Product data							
Value of shipments[5]	40,543	45,200	47,000	58,200	11.5	4.0	23.8
Value of shipments (1982$)	39,855	43,050	44,350	47,400	8.0	3.0	6.9
Shipments price index (1982 = 100)[6]	101.8	105.1	106.2	105.7	3.2	1.0	-0.5
Trade data							
Value of imports (ITA)[7]	1,342	1,808	2,150	2,435	34.7	18.9	13.3
Value of exports (ITA)[8]	1,948	2,094	2,050	2,050	7.5	-2.1	N.C.

[1] Estimated except for exports and imports
[2] Estimated
[3] Forecast
[4] Value of all products and services sold by the Plastics Materials and Resins industry
[5] Value of products classified in the Plastics and Resins industry produced by all industries
[6] Developed by the Office of Industry Assessment, ITA
[7] Import data are developed by the chapter author
[8] Export data are developed by the chapter author
SOURCE: U.S. Department of Commerce: Bureau of the Census, Bureau of Economic Analysis, International Trade Administration, (ITA). Estimates and forecasts by ITA.
N.C. =No Change

GENERAL ECONOMIC STATISTICS

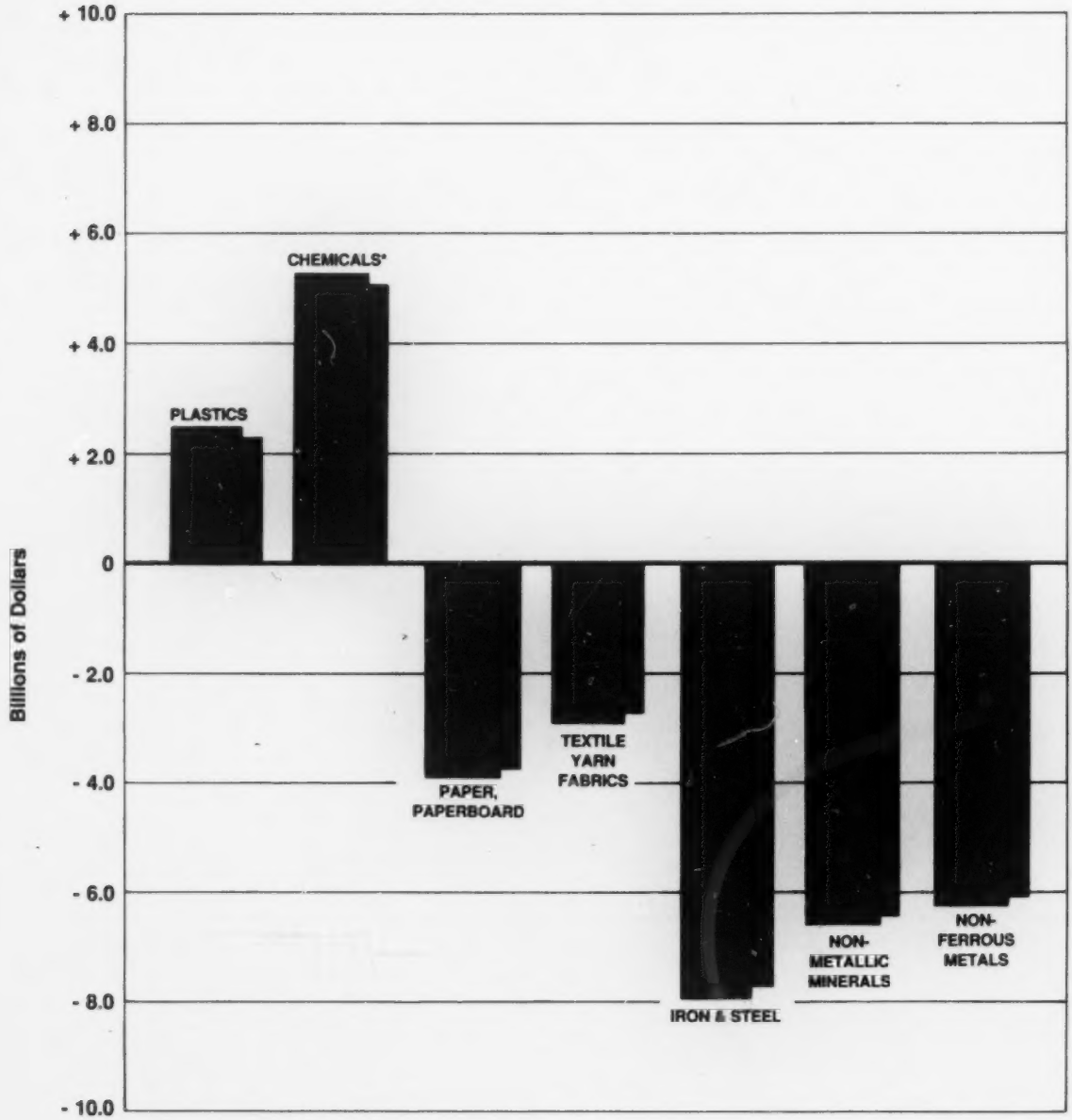
COMMODITY — BALANCE OF TRADE

(in millions of dollars)

	EXPORTS	IMPORTS	DIFFERENCE
Plastics Materials & Resins			
1982	3,650	766	+2,884
1983	3,732	1,098	+2,634
1984	4,050	1,477	+2,573
1985	3,777	1,619	+2,158
1986	4,301	1,822	+2,479
Chemicals (except plastics)			
1982	16,240	8,727	+7,513
1983	16,019	9,681	+6,338
1984	18,286	12,121	+6,165
1985	17,982	12,801	+5,181
1986	18,465	13,039	+5,426
Paper, Paperboard			
1982	2,653	3,848	−1,195
1983	2,553	4,215	−1,662
1984	2,620	5,571	−2,951
1985	2,328	5,975	−3,647
1986	2,602	6,357	−3,755
Textile, Yarn, Fabrics			
1982	2,784	2,807	− 23
1983	2,368	3,225	− 857
1984	2,382	4,475	−2,093
1985	2,366	4,871	−2,505
1986	2,570	5,693	−3,123
Iron and Steel			
1982	1,804	4,487	−2,683
1983	1,478	6,791	−5,313
1984	1,348	10,844	−9,496
1985	1,234	10,217	−8,983
1986	1,081	8,875	−7,794
Nonmetallic Minerals, n.e.c.			
1982	2,168	9,612	−7,444
1983	1,770	5,330	−3,560
1984	1,865	6,889	−5,024
1985	1,821	7,391	−5,570
1986	1,866	8,453	−6,587
Nonferrous Metals			
1982	2,094	5,320	−3,226
1983	2,033	7,422	−5,389
1984	2,028	8,001	−5,973
1985	1,798	6,978	−5,180
1986	1,491	7,690	−6,199

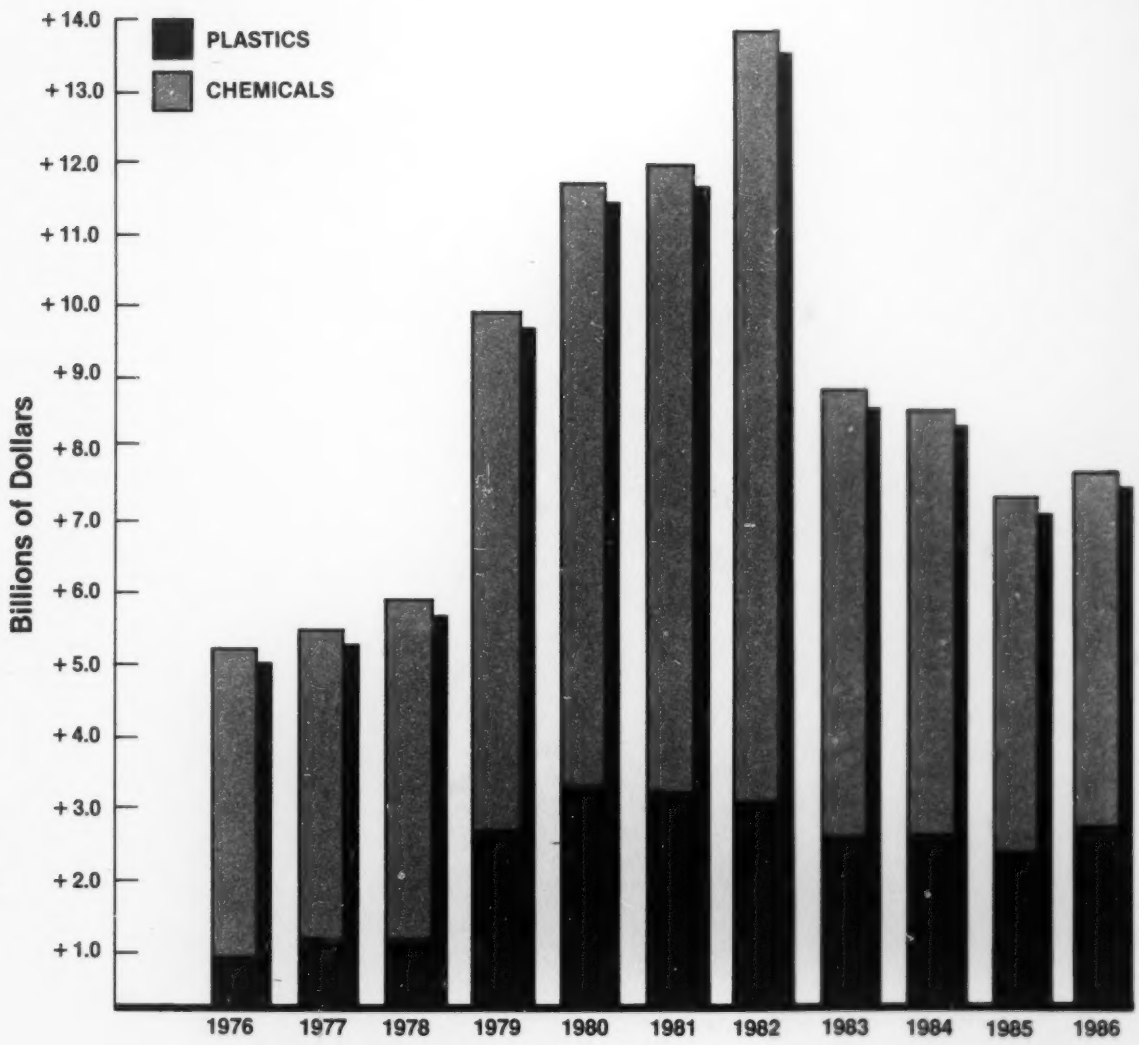
Source: U.S. Dept. of Commerce; FT 135(U.S. Imports), FT 410(U.S. Exports)

U.S. BALANCE OF TRADE-1986



Source: Department of Commerce
*Chemicals exclude plastics

PLASTICS & CHEMICALS BALANCE OF TRADE 1976 - 1986



PRODUCER PRICE INDEXES
[1967 = 100]

YEAR	COMMODITY GROUP					
	NON-METALLIC MINERAL PRODUCTS	METALS & METAL PRODUCTS	INDUSTRIAL COMMODITIES	CHEMICALS & ALLIED PRODUCTS	PLASTICS RESINS & MATERIALS	PULP, PAPER & ALLIED PRODUCTS
1968	103.7	102.6	102.5	99.8	91.9	101.1
1969	107.7	108.5	106.0	99.9	90.4	104.0
1970	113.3	116.7	110.0	102.2	90.7	108.2
1971	122.4	119.0	114.0	104.2	88.9	110.1
1972	126.1	123.5	117.9	104.2	88.7	113.4
1973	130.2	132.8	125.9	110.0	92.1	122.1
1974	153.2	171.9	153.8	146.8	143.8	151.7
1975	174.0	185.6	171.5	181.3	180.9	170.4
1976	186.3	195.9	182.4	187.2	194.0	179.4
1977	200.5	209.0	195.1	192.8	197.5	186.4
1978	228.8	227.1	209.4	198.8	199.9	195.6
1979	248.6	259.3	236.5	222.3	235.9	219.0
1980	282.9	286.4	274.3	260.3	279.5	249.2
1981	309.5	300.4	304.1	287.7	289.2	273.8
1982	318.6	302.0	312.4	292.3	283.3	288.7
1983	325.3	307.1	315.8	292.9	290.2	297.7
1984	337.2	316.0	310.3	300.9	308.5	318.2
1985	347.7	314.9	323.9	302.9	304.5	327.3

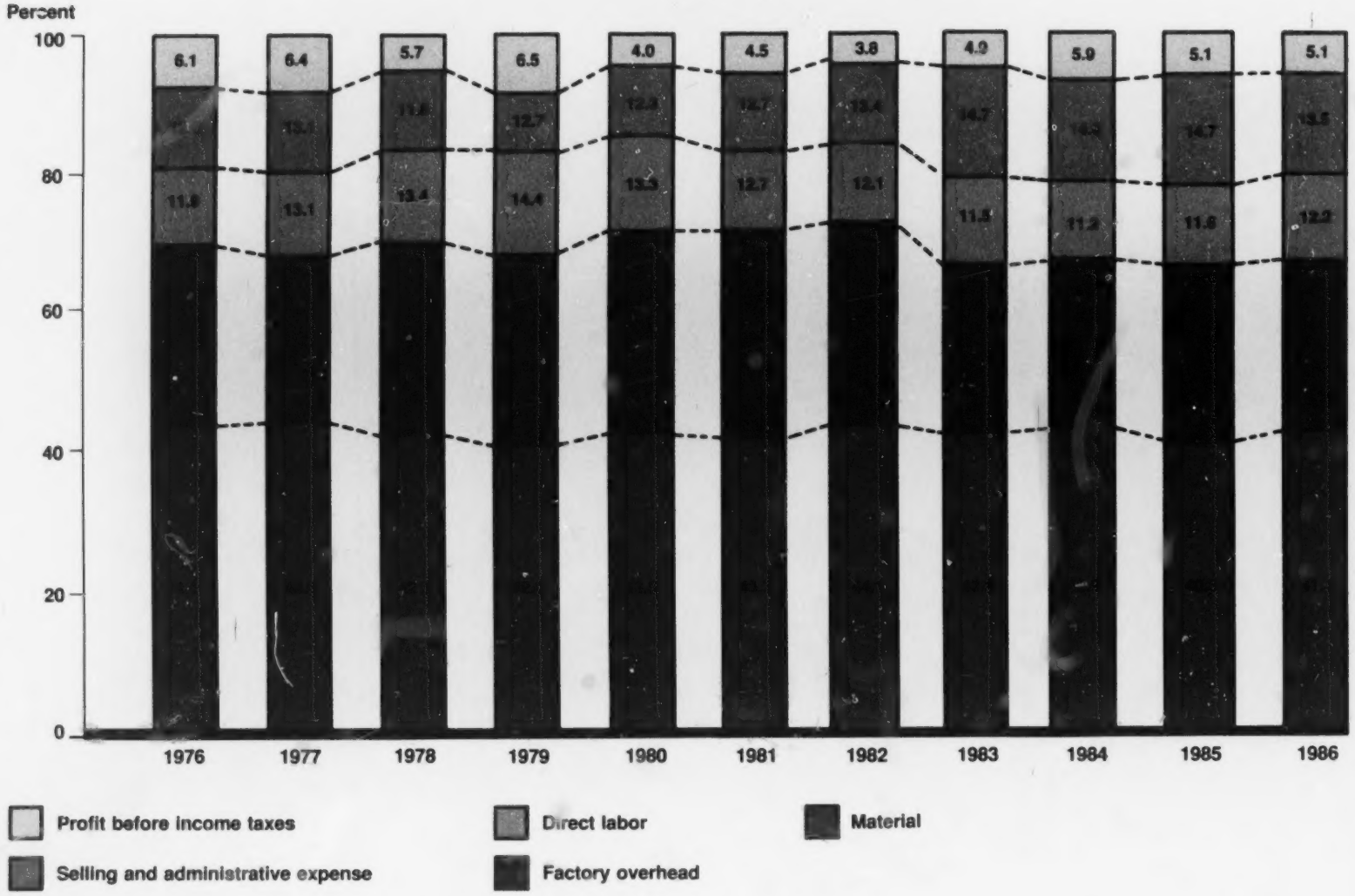
Source: Dept. of Labor, Bureau of Labor Statistics

PROFILE OF 25 BIGGEST MANUFACTURING INDUSTRIES

RELATIVE 1986 RANK	SIC	INDUSTRY	1986 INDUSTRY SHIPMENTS (BIL. 1982$)
1	2911	Petroleum refining	$201,702
2	3711	Motor vehicles & car bodies	90,794
3	3573	Electronic computing equip.	65,800
4	3312	Steel mill products	53,137
5	3714	Motor vehicle parts & accessories	49,028
6	**3079**	**Miscellaneous plastics products**	**45,500**
7	2011	Meat packing plants	42,161
8	3662	Radio & TV communication equipment	40,991
9	2869	Industrial organic chemicals	38,215
10	3674	Semiconductors & related devices	35,564
11	2752	Commercial printing & lithographic	32,900
12	3721	Aircraft	30,400
13	2711	Newspapers	22,938
14	2834	Pharmaceuticals preparations	22.215
15	**2821**	**Plastics materials & resins**	**20,997**
16	2026	Fluid milk	19,033
17	2086	Soft drinks	18,514
18	2819	Industrial inorganic chemicals, n.e.c.	15,204
19	3585	Refrigeration & heating equipment	14,200
20	3724	Aircraft engines & engine parts	14,800
21	2013	Sausage & other materials	14,079
22	3671	Guided missiles & space vehicles	14,000
23	3728	Aircraft equipment, n.e.c.	13,500
24	2051	Bread, cake & related products	13,243
25	2653	Corrugated & solid fiber boxes	12,765

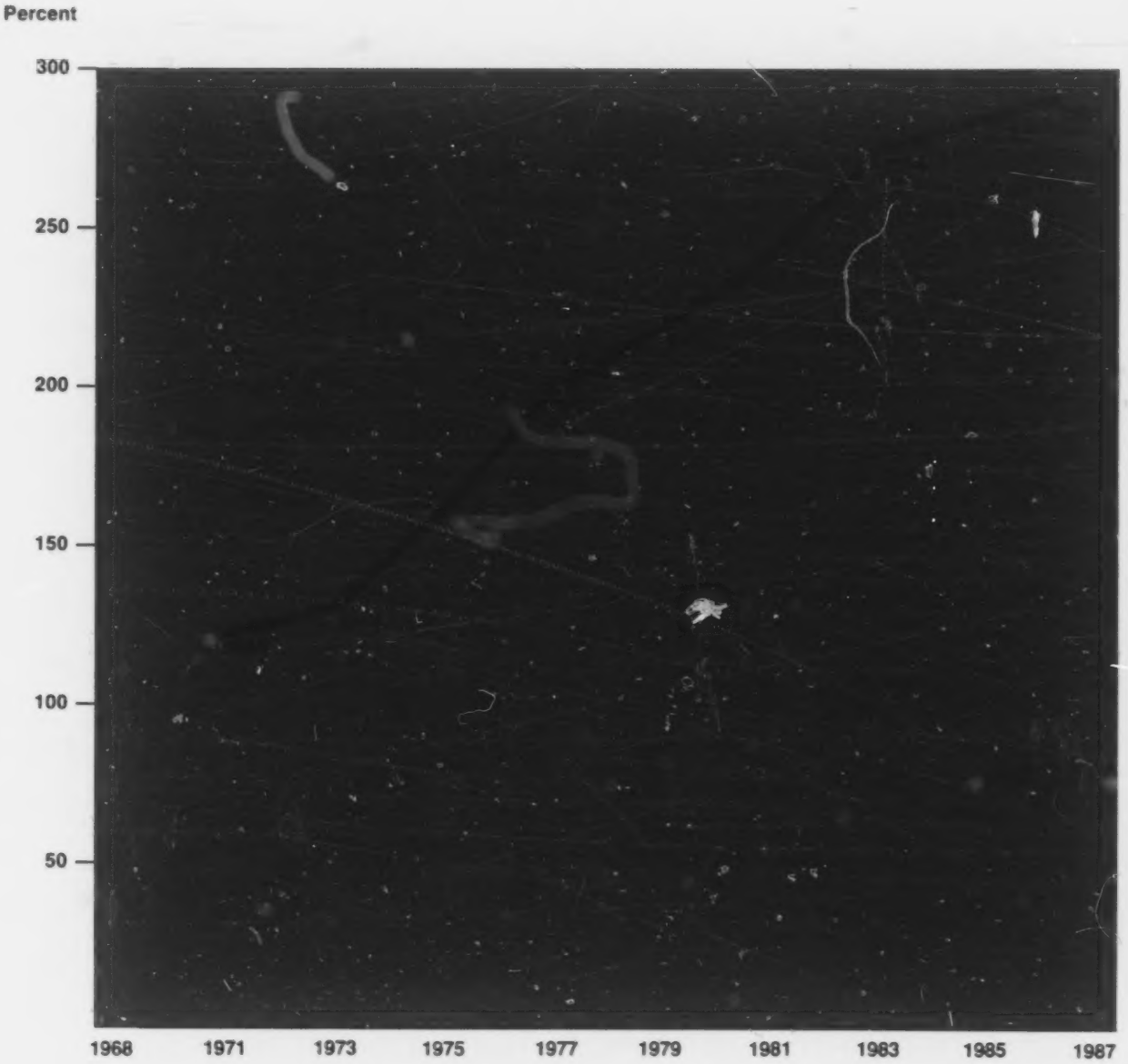
Source: Department of Commerce

TREND IN DISTRIBUTION OF SALES DOLLAR
PLASTICS PROCESSING COMPANIES
1976 - 1986



Source: SPI Financial & Operating Ratios Survey No.25 -1986

PLASTICS PROCESSING COMPANIES
TREND IN STRAIGHT-TIME HOURLY WAGES
1971 - 1986 (1968 = 100)



Source: SPI Labor Survey No.48 - 1986

TOP 10 STATES OF THE PLASTICS INDUSTRY—1985*

NUMBER OF ESTABLISHMENTS[1]

1. California	3,253
2. New York	1,520
3. Illinois	1,419
4. Ohio	1,399
5. New Jersey	1,265
6. Michigan	1,261
7. Texas	1,234
8. Pennsylvania	1,077
9. Massachusetts	959
10. Florida	909

NUMBER OF EMPLOYEES[2]

1. California	121,200
2. Ohio	86,800
3. Illinois	76,500
4. New Jersey	66,800
5. New York	65,500
6. Pennsylvania	60,600
7. Michigan	58,400
8. Texas	56,200
9. Massachusetts	55,800
10. Indiana	45,900

VALUE OF SHIPMENTS[3] ($MILLION)

1. Texas	$13,330
2. California	13,048
3. Ohio	11,072
4. Illinois	9,581
5. New Jersey	8,705
6. Pennsylvania	7,111
7. New York	6,794
8. Massachusetts	5,968
9. Michigan	5,590
10. Indiana	5,037

NEW CAPITAL EXPENDITURES ($ MILLION)

1. Texas	$702
2. California	609
3. Ohio	572
4. Illinois	448
5. Pennsylvania	298
6. New Jersey	264
7. Massachusetts	250
8. New York	240
9. No. Carolina	203
10. Michigan	201

PAYROLL ($ MILLION)

1. California	$2,502
2. Ohio	1,977
3. Illinois	1,692
4. New Jersey	1,430
5. Texas	1,338
6. Pennsylvania	1,338
7. New York	1,292
8. Michigan	1,195
9. Massachusetts	1,088
10. Indiana	932

*The plastics industry includes establishments producing resins, machinery, fabricated products, and molds.

[1] A company operating at more than one location is required to file a separate report for each location (establishment).

[2] Includes all employees, administrative and manufacturing.

[3] Covers the received or receivable net selling values, f.o.b. plant (exclusive of freight and taxes), of all products shipped, both primary and secondary, as well as all miscellaneous receipts, such as receipts for contract work performed for others, installation and repair, sales of scrap, and sale of products bought and resold without further processing.

Source: Dept. of Commerce, Bureau of the Census
SPI estimates

PLASTICS PROCESSING INDUSTRY BY SALES GROUPS—1986

SALES LESS THAN $5 MILLION				SALES $5-$10 MILLION		
Less Profitable*	Median	More Profitable**	Operating Statements	Less Profitable*	Median	More Profitable**
100.0	100.0	100.0	Net Sales	100.0	100.0	100.0
.6	.3	1.3	Less Adjustments & Allowances	.8	.9	1.2
99.4	99.7	98.7	Net Sales	99.2	99.1	98.8
35.4	38.3	37.4	Direct Materials	39.0	39.9	37.7
16.5	16.6	12.5	Direct Labor	11.7	11.2	8.6
9.2	4.0	5.6	Indirect Labor	9.1	7.8	5.8
4.2	5.2	2.5	Utilities	3.4	3.1	2.9
3.9	2.5	3.2	Depreciation	3.7	3.9	3.7
17.1	15.9	12.9	Other Mfg. Expense	11.7	12.2	13.0
.1	1.0	0	Net on Tool Transactions	.4	0	0
6.8	1.1	3.2	Selling Expenses	7.6	5.1	4.3
10.0	10.2	10.4	Administrative Expense	11.6	9.1	7.6
(3.8)	4.3	11.0	Operating Earnings	1.0	6.8	15.2
(1.2)	1.8	3.2	Other Income or (Expense)	.8	1.0	5.1
(2.6)	2.5	7.8	Profit Before Income Taxes	.2	5.8	10.1
0	.9	2.6	Income Taxes	(.1)	2.1	4.0
(2.6)	1.6	5.2	PROFIT AFTER INCOME TAXES	.3	3.7	6.1
228.3%	249.3%	255.1%	Sales as Percentage of Total Assets	220.1%	196.9%	215.0%
			Balance Sheets			
5.0	5.0	12.4	Cash	4.3	9.1	5.2
26.0	28.1	25.7	Accounts & Notes Receivable	31.1	25.7	25.7
25.2	18.8	17.2	Inventory	20.9	18.9	18.4
4.1	7.0	5.1	Other Current Assets	3.9	5.7	6.1
60.3	58.9	60.4	CURRENT ASSETS	60.2	59.4	55.4
18.0	4.4	7.2	Land & Buildings, at Cost	14.5	12.4	11.5
6.6	.5	1.5	Depreciation Reserve	4.4	3.2	1.9
61.1	34.3	56.1	Machinery & Equipment, at Cost	69.4	62.3	55.1
36.1	7.1	30.0	Depreciation Reserve	49.1	41.0	28.1
3.3	10.0	7.8	Other Long-Term Assets	9.4	10.1	8.0
100.0	100.0	100.0	TOTAL ASSETS	100.0	100.0	100.0
8.2	6.1	5.9	Current Portion of Term Debt	7.8	2.8	7.0
15.3	19.6	20.1	Notes Payable	21.7	11.7	8.9
18.9	26.5	14.3	Accounts Payable, Trade	15.2	13.3	12.3
11.3	6.6	7.8	Other Payables & Accruals	12.9	11.1	11.4
53.7	58.8	48.1	CURRENT LIABILITIES	57.6	38.9	39.6
9.9	8.5	3.4	Other Long-Term Debt	9.6	5.7	2.0
63.6	67.3	51.5	TOTAL LIABILITIES	67.2	44.6	41.6
36.4	32.7	48.5	EQUITY (NET WORTH)	32.8	55.4	58.4
			Statistical Data			
.1%	3.1%	7.3%	Percent Change in Sales, '86 vs '85	.3%	9.9%	8.5%
46.4	33.2	32.6	Cost of Sales/Inventory	43.7	44.3	42.8
41.6	41.1	36.3	Average Collection Period	51.6	47.6	43.6
(5.9%)	6.2%	19.9%	Profit Before Income Taxes/Assets	.4%	11.4%	21.7%
(16.3%)	12.2%	27.4%	Net Income/Equity	2.0%	13.2%	22.5%

*PBIT less than 2.5 percent
**PBIT more than 2.5 percent

*PBIT less than 5.8 percent
**PBIT more than 5.8 percent

Source: SPI Financial & Operating Ratios Survey No. 25-1986

PLASTICS PROCESSING INDUSTRY BY SALES GROUPS—1986

SALES $10 MILLION OR MORE			
Less Profitable*	Median	More Profitable**	Operating Statements
100.0	100.0	100.0	Net Sales
1.5	.3	1.0	Less Adjustments & Allowances
98.5	99.7	99.0	Net Sales
46.5	46.4	40.2	Direct Materials
10.2	11.7	10.1	Direct Labor
11.4	8.5	8.1	Indirect Labor
3.2	2.1	2.3	Utilities
2.1	2.9	3.1	Depreciation
8.7	8.6	8.1	Other Mfg. Expense
.5	0	.1	Net on Tool Transactions
5.0	4.8	4.7	Selling Expenses
6.4	6.3	6.5	Administrative Expense
4.5	8.4	15.5	Operating Earnings
1.5	1.6	3.7	Other Income or (Expense)
3.0	6.8	11.8	Profit Before Income Taxes
.5	2.8	4.8	Income Taxes
2.5	4.0	7.0	PROFIT AFTER INCOME TAXES
148.1%	195.7%	223.9%	Sales as Percentage of Total Assets
			Balance Sheets
.5	4.2	6.5	Cash
21.4	24.9	21.2	Accounts & Notes Receivable
15.6	16.4	15.0	Inventory
3.1	6.9	5.2	Other Current Assets
40.6	52.4	47.9	CURRENT ASSETS
20.5	26.4	21.2	Land & Buildings, at Cost
4.2	9.2	6.8	Depreciation Reserve
54.0	64.0	65.1	Machinery & Equipment, at Cost
22.9	35.6	33.7	Depreciation Reserve
12.0	2.0	6.3	Other Long-Term Assets
100.0	100.0	100.0	TOTAL ASSETS
2.9	1.3	1.9	Current Portion of Term Debt
6.6	5.7	5.6	Notes Payable
8.7	9.0	12.1	Accounts Payable, Trade
13.8	10.2	11.4	Other Payables & Accruals
32.0	26.2	31.0	CURRENT LIABILITIES
16.1	9.0	10.0	Other Long-Term Debt
48.1	35.2	41.0	TOTAL LIABILITIES
51.9	64.8	59.0	EQUITY (NET WORTH)
			Statistical Data
6.9%	13.4%	21.0%	Percent Change in Sales, '86 vs '85
46.0	38.2	33.5	Cost of Sales/Inventory
52.7	46.4	34.6	Average Collection Period
4.4%	13.3%	26.4%	Profit Before Income Taxes/Assets
7.1%	7.8%	26.6%	Net Income/Equity

*PBIT less than 6.8 percent

**PBIT more than 6.8 percent

Source: SPI Financial & Operating Ratios Survey No. 25-1986

FEEDSTOCKS & ADDITIVES

PLASTICS DERIVED FROM MAJOR FEEDSTOCKS*

(in millions of pounds)

FEEDSTOCK	Total Production		Plastics Derivatives		Plastics % of Total	
	1985	1984	1985	1984	1985	1984
Ethylene	30,550	31,175	21,940	20,805	72	67
Propylene	13,020	13,680	7,675	7,450	59	54
Benzene	9,875	9,800	7,495	7,305	76	75

* These data should not be construed to represent the entire feedstock needs of the U.S. plastics industry. They are based on 1984 and 1985 plastics production only and do not include feedstock needs for monomers, additives, and other chemicals not used in domestic production.

PLASTICS CONSUMPTION OF FEEDSTOCKS—1985

(millions of pounds)

Ethylene	Styrene Butadiene Latex	185	0.8
	Styrene Acrylonitrile	20	0.1
	Acrylonitrile Butadiene Styrene	185	0.8
	Polyvinyl acetate	270	1.2
	Polyethylene	16,340	74.5
	Polystyrene	1,360	6.2
	Other Styrenes	80	0.4
	Polyvinyl chloride	3,500	16.0
		21,940	100.0%
Propylene	Epoxy	150	2.0
	Phenolic	1,250	16.3
	Polypropylene	5,650	73.6
	Polyester	265	3.5
	Styrene Acrylonitrile	35	0.4
	Acrylonitrile Butadiene Styrene	325	4.2
		7,675	100.0%
Benzene	Acrylonitrile Butadiene Styrene	505	6.7
	Styrene Acrylontrile	55	0.7
	Styrene Butadiene Latex	435	5.8
	Polystyrene	3,700	49.4
	Other Styrenes	215	2.9
	Epoxy	260	3.5
	Polyester	275	3.7
	Nylon	565	7.5
	Phenolic	1,485	19.8
		7,495	100.0%

Source: International Trade Commission, SRI International, and SPI estimates.

ADDITIVES FOR PLASTICS

ADDITIVE LUBRICANTS

These materials are added to plastics to assist flow in calendering, molding and extrusion by lubricating the metal surfaces in contact with the plastic. They also assist in knitting and wetting of the resin in mixing and milling operations. To be effective, lubricants must be compatible with the resins in which they are used, must not adversely affect the properties of end-products, and must be easily combined.

Examples: stearic acid, waxes, fatty acid esters, fatty acid amines.

ANTIOXIDANTS

They inhibit the oxidation of materials exposed to air or oxygen at normal or elevated temperatures. They are used in plastics which are subject to oxidative degradation, such as polyolefins, ABS, polystyrene, acetal and polyphenylene oxide.

Examples: alkylated phenols, amines, organic phosphites and phosphates, esters.

ANTISTATS

Chemicals which impart a slight to moderate degree of electrical conductivity to plastics compounds, thus preventing the accumulation of electrostatic charges on finished articles. They may be incorporated in the materials before molding, or applied to their surfaces after molding. They function either by being inherently conductive or by absorbing moisture from the air.

Examples: quaternary ammonium compounds, anionics, amines.

BLOWING AGENTS [FOAMING AGENTS]

Substances which alone or in combination with other substances are capable of producing a cellular structure in a plastic or rubber mass. Thus, the term includes compressed gases which expand when pressure is released, soluble solids that leave pores when leached out, liquids that develop cells when they change to gases, and chemical agents that decompose or react under the influence of heat to form a gas.

Examples: azodicarbonamide, modified azos, OBSH, HTBA.

COLORANTS

Dyes or pigments which impart color to plastics. The dyes are synthetic or natural compounds of submicroscopic or molecular size, soluble in most common solvents, yielding perfectly transparent colors. The pigments are organic and inorganic substances with larger particle sizes and usually insoluble in the common solvents. Colorants are added to plastics by dry coloring (tumbling the colorant with the base or compounded resin); by extrusion coloring (extruding a dry colored mixture and chopping it into pellets to be reprocessed); by masterbatching; or by stirring colorants or dispersions thereof into liquid plastisols or resin systems.

Examples: titanium dioxide, iron oxides, anthraquinones, carbon black.

FLAME RETARDANTS

Materials that reduce the tendency of plastic articles to burn. They are usually incorporated as additives during compounding, but sometimes are applied to surfaces of finished articles.

Examples: antimony trioxide, chlorinated paraffins, bromophenols.

HEAT STABILIZERS

Agents used in compounding some plastics to assist in maintaining the physical and chemical properties of the compounded materials at suitable values throughout the processing and service life of the material and/or the parts made therefrom. They protect plastics from the effects of heat such as changes in color, decrease in mechanical and electrical properties, and undesirable surface conditions.

Examples: lead, barium-cadmium, tin, calcium-zinc.

ORGANIC PEROXIDES

Thermally decomposable compounds which can initiate polymerization reactions and effect cross-linking upon decomposition. The rate of decomposition can be controlled by means of promoters or accelerators added to the system to increase the decomposition rate; or by inhibitors when it is desired to retard the decomposition.

Examples: MEK peroxide, benzoyl peroxide, alkyl peroxide, peresters.

PLASTICIZERS

Materials incorporated in a plastic or elastomer to increase its flexibility, workability or distensibility. Most plasticizers are nonvolatile organic liquids or low-melting point solids, which function by reducing the normal intermolecular forces in a resin thus permitting the macromolecules to slide over one another more freely.

Examples: adipates, azelates, trimellitates, DOP/DIOP/DIDP.

ULTRAVIOLET STABILIZERS (UV LIGHT ABSORBERS)

Chemical agents which absorb or screen out radiation beyond the violet end of the spectrum of visible radiations. Such radiation has sufficient energy to initiate reactions leading to the degradation of many plastics. These agents are often combined with other additives, e.g. heat stabilizers and antioxidants, with which they act in synergistic fashion.

Examples: benzophenones, benzotriazole, salicylates.

Source: Whittington's Dictionary of Plastics

DEFINITIONS OF PLASTICS

ACETAL

An engineering thermoplastic produced by the polymerization of purified formaldehyde [CH_2O] into both homopolymer and copolymer types. Typical applications are found in consumer products, automotive parts, and industrial machinery parts.

ACRYLICS

A family of thermoplastic resins of acrylic esters [$CH_2CHCOOR$] or methacrylic esters [$CH_2C(CH_3)COOR$]. The acrylates may be methyl, ethyl, butyl, or 2-ethylhexyl. Usual methacrylates are the methyl, ethyl, butyl, laural and stearyl. Typical applications are found in lighting fixtures, glazing and automotive parts.

ACRYLONITRILE BUTADIENE STYRENE

A class of thermoplastic terpolymers including a range of resins, all prepared with usually more than 50% styrene [$C_6H_5CHCH_2$] and varying amounts of acrylonitrile [CH_2CHCN] and butadiene [$CH_2CHCHCH_2$]. The three components are combined by a variety of methods involving polymerization, graft copolymerization, physical mixtures and combinations thereof. Typical applications are found in appliances, automotive parts, pipe, and business machine and telephone components.

ALKYDS

Thermosetting unsaturated polyester resins produced by reacting an organic alcohol with an organic acid, dissolved in and reacted with unsaturated monomers such as styrene [$C_6H_5CHCH_2$], diallyl phthalate [$C_6H_4(COOCH_2CHCH_2)_2$], diacetone acrylamide [$CH_3COCH_2C(CH_3)_2CHCHCONH_2$] or vinyl toluene [$CH_2CHC_6H_4CH_2$]. Typical applications are found in electrical uses, automotive parts, and as coatings.

CELLULOSICS

A family of thermoplastic resins manufactured by chemical modification of cellulose [$(C_6H_{10}O_5)_n$]. Included are: *cellophane*—regenerated cellulose made by mixing cellulose xanthate [ROCSSH] with a dilute sodium hydroxide [NaOH] solution to form a viscose, then extruding the viscose into an acid bath for regeneration; *cellulose acetate*—an acetic acid ester [$CH_3COOC_2H_5$] of cellulose; *cellulose acetate butyrate*—a mixed ester produced by treating fibrous cellulose with butyric acid [$CH_3CH_2CH_2COOH$], butyric anhydride [$(CH_3CH_2CH_2CO)_2O$], acetic acid [CH_3COOH] and acetic anhydride [$(CH_3CO)_2O$] in the presence of sulfuric acid [H_2SO_4]; *cellulose propionate*—formed by treating fibrous cellulose with propionic acid [$CH_3CH_2CO_2H$] and acetic acid and anhydrides in the presence of sulfuric acid; *cellulose nitrate*—made by treating fibrous cellulosic materials with a mixture of nitric [HNO_3] and sulfuric acids. Typical applications of cellulosics are found in packaging, consumer products, and automotive parts.

COUMARONE-INDENE

Thermoplastic resin obtained by heating mixtures of coumarone [C_8H_6O] and indene [$C_6H_4CH_2CHCH$] with sulfuric acid (H_2SO_4) to promote polymerization. These resins have no commercial applications when used alone. They are used primarily as processing aids, extenders and plasticizers with other resins in asphalt floor tile.

DIALLYL PHTHALATE(DAP)

The term DAP is used both for the monomeric and polymeric forms. The monomer [$C_6H_4(COOCH_2CHCH_2)_2$] is used as a cross-linking agent in unsaturated polyester resins. As a polymer, it is used in the production of thermosetting molding powders, casting resins and laminates.

EPOXY

Thermosetting resins, that, in the uncured form, contain one or more reactive epoxide or oxirane groups . These epoxide groups serve as cross-linking points in the subsequent curing step, in which the uncured epoxy is reacted with a curing agent or hardener. Cross-linking is accomplished through the epoxide groups as well as through hydroxyl groups that may be present. Most conventional unmodified epoxy resins are produced from epichlorohydrin (chloropropylene oxide) [CH_2OCHCH_2Cl] and bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$]. The other types of epoxy resins are phenoxy resins, novolac resins, and cycloaliphatic resins. Epoxy resins are used as protective coatings, bonding adhesives, in building and construction, and electrical uses, plus many other uses.

FLUOROPOLYMERS

A family of thermoplastic resins analogous to polyethylene in which some of the hydrogen atoms attached to the carbon chain are replaced by fluorine or fluorinated alkyl groups. In some cases, other halogens such as chlorine are also part of the molecule. The most common commercial fluoropolymers are: *FEP* (fluorinated ethylene-propylene) from tetrafluoroethylene [C_2F_4] and hexafluoropropylene [C_3F_6]; *PTFE* (polytetrafluoroethylene) from the polymerization of tetrafluoroethylene and ethylene [C_2H_4]; *PFA* (perfluoroalkoxy) from tetrafluoroethylene and perfluoropropyl vinyl ether [$C_3H_7C_4OF_5$]; *PCTFE* (polychlorotrifluoro-ethylene) from chlorotrifluoro-ethylene monomer [C_2F_3Cl]; *CTFE-VDF* (polychlorotrifluoroethylenevinylidene fluoride) from chlorotrifluoroethylene and vinylidene fluoride [$C_2H_2F_2$]; *E-CTFE* (polyethylene-chlorotrifluoroethylene) from chlorotrifluoroethylene and ethylene; *PVDF* (polyvinylidene fluoride) from vinylidene fluoride monomer; and, *PVF* (polyvinyl fluoride) from vinyl fluoride monomer [C_2H_3F]. Typical applications for fluoropolymers are found in electrical/electronic uses and pipe and chemical processing equipment.

MELAMINE-FORMALDEHYDE

Thermosetting resins formed by the condensation reaction of formaldehyde [HCHO] and melamine [$C_3N_3(NH_2)_3$]. The chemistry is analogous to that of urea-formaldehyde except that the three amino groups of melamine provide more possibilities for cross-linking, are more highly reactive, and all six hydrogen atoms of melamine will react, forming the hexamethyl compound. Typical applications are found in bonding and adhesives, coatings, and consumer products.

NITRILE RESINS

Thermoplastic resins composed of acrylonitrile [CH_2CHCN], along with co-monomers such as acrylates, methacrylates, butadiene [$CH_2CHCHCH_2$] and styrene [$C_6H_5CHCH_2$]. Both straight copolymers and copolymers grafted onto elastomeric backbones are available. The unique property of these materials is outstanding resistance to passage of gases and water vapor, making them useful in packaging applications.

NYLON

A generic name for a family of long-chain polyamide engineering thermoplastics which have recurring amide groups [-CO-NH-] as an integral part of the main polymer chain. Nylons are synthesized from intermediates such as dicarboxylic acids, diamines, amino acids and lactams, and are identified by numbers denoting the number of carbon atoms in the polymer chain derived from specific constituents, those from the diamine being given first. The second number, if used, denotes the number of carbon atoms derived from a diacid. Commercial nylons are as follows: *nylon 4* (polypyrrolidone)—a polymer of 2-pyrrolidone [$CH_2CH_2CH_2C(O)NH$]; *nylon 6* (polycaprolactam)—made by the polycondensation of caprolactam [$CH_2(CH_2)_4NHCO$]; *nylon 6/6*—made by condensing hexamethylenediamine [$H_2N(CH_2)_6NH_2$] with adipic acid [$COOH(CH_2)_4COOH$]; *nylon 6/10*—made by condensing hexamethylenediamine with sebacic acid [$COOH(CH_2)_8COOH$]; *nylon 6/12*—made from hexamethylenediamine and a 12-carbon dibasic acid; *nylon 11*—produced by polycondensation of the monomer 11-amino-undecanoic acid [$NH_2CH_2(CH_2)_9COOH$]; *nylon 12*—made by the polymerization of laurolactam [$CH_2(CH_2)_{10}CO$] or cyclododecalactam, with 11 methylene units between the linking -NH-CO- groups in the polymer chain. Typical applications for nylons are found in automotive parts, electrical/electronic uses, and packaging.

PETROLEUM RESINS

Thermoplastic resins obtained from a variable mixture of unsaturated monomers recovered as a by-product from cracked and distilled petroleum streams. They also contain indene [$C_6H_4CH_2CHCH$], which is copolymerized with a variety of other monomers including styrene [$C_6H_5CHCH_2$], vinyl toluene [$CH_2CHC_6H_4CH_3$], and methyl indene [$C_6H_3CH_3CH_2CHCH$]. Typical applications are found in adhesives, printing inks, rubber compounding, and surface coatings.

PHENOLIC

These thermosetting resins are credited with being the first commercialized wholly synthetic polymer or plastic. The basic raw materials are formaldehyde [HCHO] and phenol [C_6H_5OH], although almost any reactive phenol or aldehyde can be used. The phenols used commercially are phenol, cresols [$CH_3C_6H_4OH$], xylenols [$(CH_3)_2C_6H_3OH$], p-t-butylphenol [$C_4H_9C_6H_4OH$], p-phenylphenol [$C_6H_5C_6H_4OH$], bisphenols [$(C_6H_4OH)_2$], and resorcinol [$C_6H_4(OH)_2$]. The aldehydes used are formaldehyde and furfural [C_4H_3OCHO]. In the uncured and semi-cured condition, phenolic resins are used as adhesives, casting resins, potting compounds, and laminating resins. As molding powders, phenolic resins can be found in electrical uses.

POLYAMIDE-IMIDE

Engineering thermoplastic resins produced by the condensation reaction of trimellitic anhydride [$OCC_6H_2C_2O_3$] and various aromatic diamines. Typical applications are found in aerospace, automotive and heavy equipment industries.

POLYARYLATES

Engineering thermoplastic resins produced by interfacial polymerization of an aqueous solution of the disodium salt of bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$] with phthalic acid chlorides [$C_6H_4(CO)_2Cl_2$] in methylene chloride (CH_2Cl_2]. The major use of polyarylates is in outdoor lighting.

POLYBUTYLENE

Thermoplastic resins produced via stereospecific Ziegler-Natta polymerization of butene-1 monomer [$CH_2CHCH_2CH_3$]. Typical applications are found in pipe and packaging film.

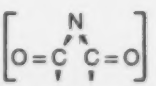
POLYCARBONATE

Engineering thermoplastic resins produced by (1) phosgenation of dihydric phenols, usually bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$], (2) ester exchange between diaryl carbonates and dihydric phenols, usually between diphenyl carbonate [$(C_6H_5O)_2CO$] and bisphenol A and (3) interfacial polycondensation of bisphenol A and phosgene [$COCl_2$]. Typical applications are found in glazing, appliances, and electrical uses.

POLYETHYLENE

A family of thermoplastic resins obtained by polymerizing the gas ethylene [C_2H_4]. Low molecular weight polymers of ethylene are fluids used as lubricants; medium weight polymers are waxes miscible with paraffin; and the high molecular weight polymers (i.e. over 6000) are the materials used in the plastics industry. Polymers with densities ranging from about .910 to .925 are called *low density;* those of densities from .926 to .940 are called *medium density;* and those from .941 to .965 and over are called *high density.* The low density types are polymerized at very high pressures and temperatures, and the high density types at relatively low temperatures and pressures. A relatively new type called linear low density polyethylene is manufactured through a variety of processes: gas phase, solution, slurry, or high pressure conversion. A high efficiency catalyst system aids in the polymerization of ethylene at lower temperatures and pressures than required in conventional low density polyethylene. Copolymers of ethylene with vinyl acetate ethyl acrylate, and acrylic acid are commercially important. Major polyethylene applications can be found in packaging, housewares, toys, and communications equipment.

POLYIMIDES

A family of thermoset and thermoplastic resins characterized by repeating imide linkages 

There are four types of aromatic polyimides: (1) condensation products made by the reaction of pyromellitic dianhydride (PMDA) [$C_6H_2(C_2O_3)_2$] and aromatic diamines such as 4,4'-diaminodiphenyl ether [$(C_6H_4NH_2)_2O$]; (2) condensation products of 3,4,3',4'-benzophenone tetracarboxylic dianhydride (BTDA) [$(C_6H_5)_2CO(C_2O_3)_2$] and aromatic amines; (3) the reaction of BTDA and a diisocyanate such as 4,4'-methylene-bis(phenylisocyanate) [$OCNC_6H_4CH_2C_6H_4NCO$]; and, (4) a polyimide based on diaminophenylindane and a dicarboxylic anhydride such as carbonyldiphthalic anhydride [$OC_6H_4(CO)_2COC_6H_4(CO)_2O$]. Thermoset polyimides are produced in condensation polymers that possess reactive terminal groups capable of subsequent cross-linking through an addition reaction. Typical applications for thermoplastic and thermosetting polyimides are in transportation and electronics.

POLYPHENYLENE OXIDE, MODIFIED

Engineering thermoplastic resins produced by the oxidative coupling of 2, 6-dimethylphenol [$(CH_3)_2C_6H_3OH$] (xylenol), then blended with impact polystyrene. Typical applications are found in electrical/electronic uses, business machine parts, appliances, and automotive parts.

POLYPHENYLENE SULFIDE

Engineering thermoplastic resins produced by the reaction of p-dichlorobenzene [$C_6H_4Cl_2$] with sodium sulfide [Na_2S]. The major use for polyphenylene sulfide is in electrical/electronic parts and automotive parts.

POLYPROPYLENE

Thermoplastic resins made by polymerizing propylene [CH_3CHCH_2] and in the case of copolymers with monomers, with suitable catalysts, generally aluminum alkyl and titanium tetrachloride mixed with solvents. The monomer unit in polypropylene is asymmetric and can assume two regular geometric arrangements: isotactic, with all methyl groups aligned on the same side of the chain, or syndiotactic, with the methyl groups alternating. All other forms, where this positioning is random, are called atactic. Commercial polypropylene contains 90-97% crystalline or isotactic PP with the remainder being atactic. Most processes remove excess atactic PP. This by-product is used in adhesives, caulks, and cable-filling compounds. Major applications of commercial PP are found in packaging, automotive, appliance and carpeting markets.

POLYSTYRENE

High molecular weight thermoplastic resins produced generally by the free-radical polymerization of styrene monomer [$C_6H_5CHCH_2$] which can be initiated by heating alone but more effectively by heating in the presence of a free-radical initiator (such as benzoyl peroxide [$(C_6H_5CO)_2O_2$]). Typical processing techniques are modified mass polymerization or solution polymerization, suspension polymerization, and expandable beads. Major markets for polystyrene are in consumer and institutional products, electrical/electronic uses, and building/construction.

POLYURETHANES

A large family of polymers based on the reaction product of an organic isocyanate with compounds containing a hydroxyl group. The commonly used isocyanates are toluene diisocyanate (TDI) [$CH_3C_6H_3(NCO)_2$], methylene diphenyl isocyanate (MDI) [$OCNC_6H_4CH_2C_6H_4NCO$], and polymeric isocyanates (PMDI), obtained by the phosgenation of polyamines derived from the condensation of aniline [$C_6H_5NH_2$] with formaldehyde [HCHO]. Polyols (with hydroxyl groups) are macroglycols which are either polyester or polyether based. Polyurethane elastomers and resins take the form of liquid casting systems, thermoplastic elastomers and resins, microcellular products, and millible gums. Typical applications are found in the automotive industry. Polyurethane foams are widely used in transportation, furniture, and construction markets.

POLYVINYL ACETATE (PVAc) & OTHER VINYLS

Polyvinyl acetate is a thermoplastic resin produced by the polymerization of vinyl acetate monomer [$CH_3COOCHCH_2$] in water producing an emulsion with a solids content of 50-55%. Most polyvinyl acetate emulsions contain co-monomers such as n-butyl acrylate, 2-ethyl hexyl acrylate, ethylene, dibutyl maleate and dibutyl fumarate. Polymerization of vinyl acetate with ethylene also can be used to produce solid vinyl acetate/ethylene copolymers with more than 50% vinyl acetate content. Polyvinyl alcohol (PVOH) is produced by methanolysis or hydrolysis of polyvinyl acetates. The reaction can be controlled to produce any degree of replacement of acetate groups. Co-polymers of replaced acetate groupings and other monomers such as ethylene and acrylate esters are commercially important. *Polyvinyl butyral* (PVB)—made by reacting PVOH with butyraldehyde [$CH_3(CH_2)_2CHO$]. *Polyvinyl formal*—made by condensing formaldehyde [HCHO] in the presence of PVOH or by the simultaneous hydrolysis and acetylization of PVAc. *Polyvinylidene chloride*—made by the polymerization of 1,1-dichloroethylene [CH_2CCl_2]. Typical applications for the above resins are found in adhesives, paints, coatings and finishes, and packaging.

POLYVINYL CHLORIDE

Thermoplastic resins produced by the polymerization of the gas vinyl chloride [CH_2CHCl]. Under pressure, vinyl chloride becomes liquified and is polymerized by one of four basic processes: suspension, emulsion, bulk, and solution polymerization. The pure polymer is hard, brittle and difficult to process, but it becomes flexible when plasticizers are added. A special class of PVC resin of fine particle size, often called dispersion grade resin, can be dispersed in liquid plasticizers to form plastisols. The addition of a volatile diluent or a solvent to the plastisol produces an organosol. Copolymers with vinyl acetate, vinylidene chloride, and maleate and fumarate esters find commercial application. Major markets for PVC are in building/construction, packaging, consumer and institutional products, and electrical/electronic uses.

STYRENE ACRYLONITRILE

Thermoplastic copolymers of styrene [$C_6H_5CHCH_2$] and acrylonitrile [CH_2CHCN]. SAN resins are random, amorphous copolymers produced by emulsion, suspension, or continuous mass polymerization. Typical uses include automobile instrument lenses and housewares.

STYRENE BUTADIENE LATEXES & OTHER STYRENE COPOLYMERS

Styrene butadiene latexes usually have a resin content of about 50%. The styrene/butadiene ratio varies from 54:46 to 80:20. Most are carboxylated by the use of such acids as maleic [HOOCCHCHCOOH], fumaric [HOOCCHCHCOOH], acrylic [$CH_2CHCOOH$], or methacrylic [$CH_2C(CH_3)COOH$]. Two types of *styrene-maleic anhydride* (SMA) [$(COCH)_2O$] are available: SMA copolymers, with and without rubber impact modifier (e.g. DYLARK®) and SMA terpolymer alloys (e.g. CADON®). *K-Resin®* is a solid styrene-butadiene copolymer resin. Acrylic monomers are also used in conjunction with styrene (or styrene plus other monomers) to produce specialty resins. For example, there are transparent terpolymers of methyl methacrylate, butadiene, and styrene (MBS), and others of acrylonitrile, an acrylic monomer, and styrene (AAS). Ion-exchange resins or divinylbenzene-modified polystyrene are another variation. SB latexes are used in carpet backing and paper coatings. The other styrenics are used in paints, coatings, and floor polishes, plus many other uses.

SULFONE POLYMERS

A family of engineering thermoplastic resins characterized by the sulfone [SO_2] group. *Polysulfone* is made by the reaction of the disodium salt of bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$] with 4,4'-dichlorodiphenyl sulfone(4,4'-DCDPS [$(C_6H_4Cl)_2SO_2$]. *Polyethersulfone* is made by the reaction of 4,4'-DCDPS with potassium hydroxide [KOH]. *Polyphenylsulfone* is similar to the other sulfone polymers. Typical applications for sulfone polymers are found in electrical/electronic uses and automotive parts.

THERMOPLASTIC POLYESTER (SATURATED)

A family of polyesters in which the polyester backbones are saturated and hence unreactive. The most common commercial types are: *PET* (polyethylene terephthalate) produced by polycondensation of ethylene glycol [CH_2OHCH_2OH] with either dimethyl terephthalate (DMT) [$C_6H_4(COOCH_3)_2$] or terephthalic acid (TPA) [$C_6H_4(COOH)_2$]; and *PBT* (polybutylene terephthalate) produced by the reaction of DMT with 1,4 butanediol [$NO(CH_2)_4OH$]. Typical applications are found in packaging, automotive, electrical, and consumer markets.

UREA-FORMALDEHYDE

Formed by the condensation reaction of formaldehyde [HCHO] and urea [$CO(NH_2)_2$]. These thermoset resins are clear water-white syrups or white powdered materials which can be dispersed in water to form colorless syrups. They cure at elevated temperatures with appropriate catalysts. Molding powders are made by adding fillers to the uncured syrups, forming a consistency suitable for compression and transfer molding. The liquid and dried resins find extensive use in laminates and chemically-resistant coatings. The molding compounds are formed into rigid electrical and decorative products.

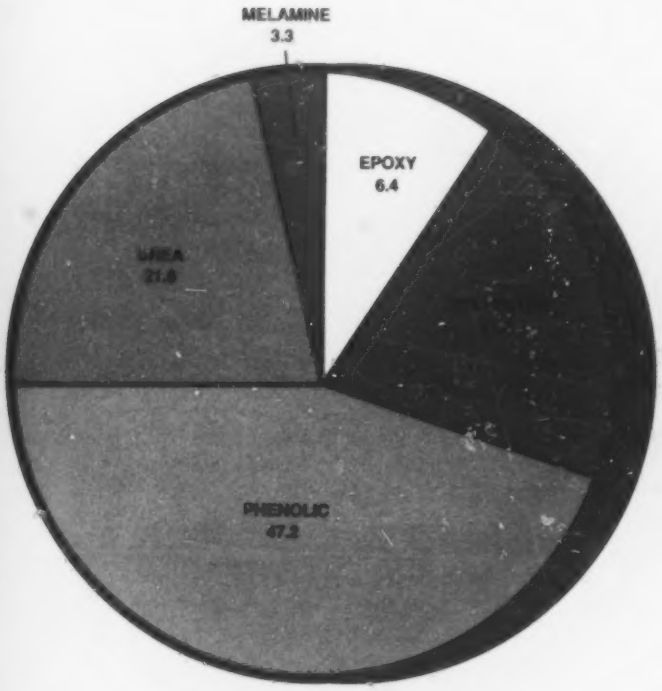
UNSATURATED POLYESTER

Thermosetting resins made by the condensation reaction between difunctional acids and glycols. The resulting polymer is then dissolved in styrene [$C_6H_5CHCH_2$] or other vinyl unsaturated monomer. The structures of the acids and glycols used and their proportions, especially the ratio of the unsaturated versus the saturated acid, and the type and amount of monomer used, are all tailored for each resin to balance economy, processing characteristics, and performance properties. One common formulation is the reaction of maleic anhydride [$(COCH)_2O$], phthalic anhydride [$C_6H_4(CO)_2O$], and propylene glycol [$CH_3CHOHCH_2OH$]. Both dicyclopentadiene [$(C_6H_5)_2$] and isophthalic acid [$C_6H_4(COOH)_2$] can be substituted for phthalic anhydride. Vinyl ester resins are linear reaction products of bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$] and epichlorohydrin [CH_2OCHCH_2Cl] that are terminated with an unsaturated acid such as methacrylic acid [$CH_2C(CH_3)COOH$]. Typical applications are found in transportation, appliances, electrical, and construction markets.

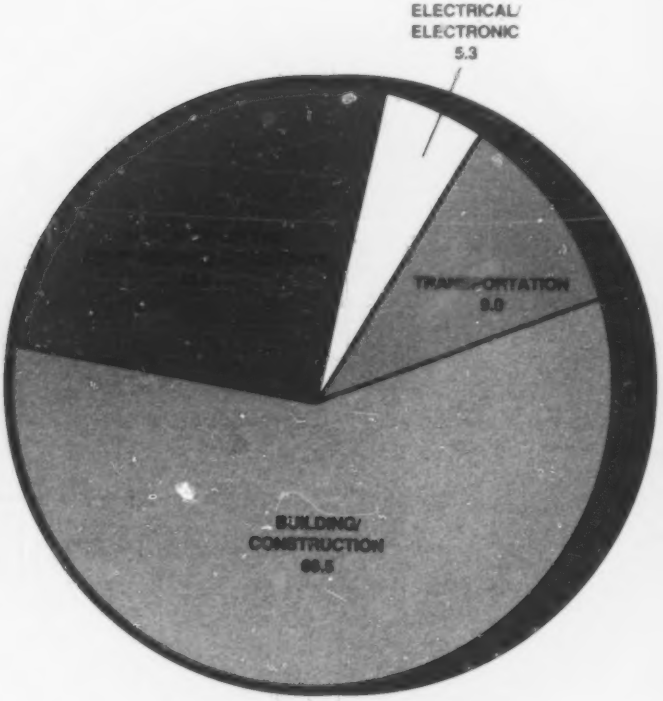
Sources: *Chemical Economics Handbook*, SRI International
Modern Plastics Encyclopedia
Whittington's Dictionary
The Condensed Chemical Dictionary

THERMOSETTING RESINS

Plastics which in their final state as finished articles are substantially infusible and insoluble. They are often liquids at some state of their manufacture or processing, which are cured by heat, catalysts or other chemical means. After being fully cured, thermosets cannot be resoftened by heat.



1986 PERCENT OF THERMOSET RESIN SALES & CAPTIVE USE BY MATERIAL



1986 PERCENT OF THERMOSET RESIN SALES & CAPTIVE USE BY MAJOR MARKET

Note: Includes data from reporting companies only
No estimates are included

Source: SPI Major Market Report, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

EPOXY

MANUFACTURERS*

Ciba-Geigy Corp.
Dow Chemical U.S.A.
Interez, Inc.
Reichhold Chemicals, Inc.
Shell Chemical Co.
Union Carbide Corp.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1986

PRODUCTION AND SALES & CAPTIVE USE
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	261	278	0.85
1978	299	316	0.86
1979	361	332	0.82
1980	315	319	0.86
1981	336	332	0.86
1982	286	301	0.82
1983	334	331	0.78
1984	406	379	0.84
1985	385	367	0.77
1986	398	376	0.85
Average Annual Growth			
1976-1986	4.9%	4.2%	

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DOMESTIC CONSUMPTION BY END-USE
(in millions of pounds)

END-USE	1982	1983	1984	1985	1986
Bonding & adhesives	15	15	20	17	19
Flooring, paving and aggregates	18	19	18	17	19
Protective coatings	122	131	153	168	160
Fiber reinforced laminates & composites	58	74	87	69	69
Tooling, casting, and molding resins	24	28	31	23	23
All other cases	25	29	29	31	29
Total	262	296	338	325	319

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

EPOXY

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	*	*	*	*	*
Packaging	*	*	*	*	*
Building/Construction	44	36	36	39	38
Electrical/Electronic	60	73	82	72	80
Furniture/Furnishings	—	*	*	*	*
Consumer & Institutional	*	—	*	*	*
Industrial/Machinery	*	*	*	*	*
Adhesives, Inks & Coatings	134	118	122	140	140
All Other	24	69	98	74	61
Exports	39	35	41	42	57
Total	301	331	379	367	376

* Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Coatings
Electrical laminates
Floor/paving aggregates
Reinforced composites
Electrical/Electronic casting
Adhesives and molding

PHENOLIC

MANUFACTURERS*

Allied Bendix
American Hoechst Corp.
Ametek, Haveg Div.
Ashland Chemical Co.
Borden Chemical Co., Inc.
Chembond Corp.
Formica Corp.
Georgia-Pacific Corp.
Inmont Corp.
Ironsides Resins, Inc.
Koppers Co.
Masonite Corp.
Occidental Chemical Corp.
Owens-Corning Fiberglas Corp.
Perkins Industries, Inc.
Plaslok Corp.
Plastics Engineering Co.
Polymer Applications, Inc.
Polyrez Co., Inc.
Raymark Industries, Inc.
Reichhold Chemicals, Inc.
Rogers Corp.
Sterling Engineered Products
Union Carbide Corp.
Valite Div., Valentine Sugars, Inc.
Van Leer Containers, Inc.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1986

PRODUCTION AND SALES & CAPTIVE USE*
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	1,458	1,400	4.27
1978	1,827	1,788	4.86
1979	1,781	1,732	4.27
1980	1,499	1,517	4.11
1981	2,333	2,375	6.12
1982	2,006	2,060	5.62
1983	2,484	2,529	5.99
1984	2,502	2,510	5.55
1985	2,621	2,640	5.56
1986	2,735	2,771	6.27

*Gross weight basis of reporting begun in 1981, so data are not comparable before then.
Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

PHENOLIC
DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

End-use	1982	1983	1984	1985	1986
Molding Compounds	192	232	238	209	206
Bonding & adhesive resins for:					
Laminating	127	166	149	142	200
Coated & bonded abrasives	25	28	23	16	19
Friction materials	25	32	35	26	29
Insulation materials	347	355	307	419	425
Foundry & shell molding	56	70	81	77	42
Plywood	1,012	1,309	1,319	1,255	1,450
Fibrous & granulated wood	146	179	184	217	244
Resins sold to Rubber Industry	23	27	30	28	31
All other	51	59	62	159	66
Protective coatings	18	19	22	23	24
All other uses	23	30	38	48	20
Total	2,045	2,506	2,488	2,619	2,756

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	129	156	150	124	85
Packaging	*	*	*	*	*
Building/Construction	1,543	1,936	1,921	1,950	2,278
Electrical/Electronic	170	176	162	128	130
Furniture/Furnishings	26	*	*	*	*
Consumer & Institutional	*	44	*	*	*
Industrial/Machinery	*	11	9	7	*
Adhesives, Inks & Coatings	73	70	80	82	68
All Other	104	113	166	328	194
Exports	15	23	22	21	16
Total	2,060	2,529	2,510	2,640	2,771

*Included in all other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Wiring devices
Connectors
Transmission parts
Pulleys
Electrical switch gear
Closures
Handles
Telephone relay systems
Rubber tackifiers
Laminating plywood
Knobs
Power brake components

UNSATURATED POLYESTER

MANUFACTURERS*

Advance Coatings Corp.
Alpha Chemical Corp.
Aristech Chemical Co.
Ashland Chemical Co.
AZS Corp.
Cargill, Inc.
Cook Paint & Varnish Co.
Dow Chemical U.S.A.
Freeman Chemical Corp.
Glidden Coatings & Resin Div. SCM Corp.
ICI Americas, Inc.
Inmont Corp.
Interplastics Corp.
Koppers Co.
Owens-Corning Fiberglas Corp.
Reichhold Chemicals, Inc.
Sterling Engineered Products
Sohio Chemical Co.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1986

PRODUCTION AND SALES & CAPTIVE USE
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	1,061	1,045	3.19
1978	1,209	1,199	3.26
1979	1,147	1,152	2.84
1980	947	949	2.57
1981	997	977	2.52
1982	865	851	2.32
1983	1,084	1,072	2.54
1984	1,232	1,231	2.72
1985	1,223	1,233	2.60
1986	1,271	1,265	2.86
Average Annual Growth			
1976-1986	2.0%	2.7%	

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

TYPICAL APPLICATIONS

Panels
Tanks
Auto components
Sanitary fixtures
Synthetic marble
Recreational vehicles
Pleasure boats
Bowling balls
Showerstalls

UNSATURATED POLYESTER
MAJOR DOMESTIC MARKETS
(in millions of pounds)

	1982	1983	1984	1985	1986
DOMESTIC REINFORCED PLASTICS, TOTAL	**629**	**818**	**939**	**949**	**947**
Marine and marine accessories	156	215	249	246	265
Transportation	65	88	99	120	107
Auto, trucks, buses, etc.	53	75	83	100	88
Other transportation	12	13	16	20	19
Construction	279	340	389	382	382
General construction	114	135	172	158	145
Bathroom components & fixtures, general purpose tanks & pipes	75	93	100	112	124
Corrosion resistant tanks, pipes, etc.	90	112	117	112	113
Electrical generation, transmission and distribution	17	26	37	27	27
Consumer goods	51	81	85	96	84
Major appliances and parts	19	21	19	21	21
Recreational goods, toys, etc.	22	40	39	42	32
Other consumer goods	10	20	27	33	31
Gel coats	31	36	43	38	42
Other reinforced	30	32	37	40	40
DOMESTIC NON-REINFORCED PLASTICS, TOTAL	**214**	**244**	**283**	**276**	**309**
Castings	103	118	161	160	173
Furniture	4	4	5	7	5
Cultured marble & onyx	62	81	107	107	121
Other	37	33	49	46	47
Autobody putty	60	61	56	61	69
Surface and protective coatings	4	5	5	6	8
Bonding and adhesives	2	2	3	2	4
Minebolt anchor resins	NA	NA	21	20	NA
Other non-reinforced	45	58	37	27	55

NA = Not Available
Source: Quarterly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET
(in millions of pounds)

MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	244	316	388	411	428
Packaging	—	—	—	—	—
Building/Construction	353	496	502	487	505
Electrical/Electronic	26	52	66	61	59
Furniture/Furnishings	3	2	11	11	11
Consumer & Institutional	95	81	72	60	70
Industrial/Machinery	—	*	*	*	24
Adhesives, Inks & Coatings	7	*	*	*	*
All Other	115	115	184	194	159
Exports	8	10	8	9	9
Total	**851**	**1,072**	**1,231**	**1,233**	**1,265**

*Included in all other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

UREA

MANUFACTURERS*

American Cyanamid Co.
Borden Chemical Co., The
Chembond Corp.
Dan River, Inc.
Georgia-Pacific Corp.
Grifftex Chemicals, Inc.
Harborchem, Inc.
Interez, Inc.
Monsanto Co.
Perkins Industries
Perstorp Compounds, Inc.
Reichhold Chemicals, Inc.
Sterling Engineered Products
Valchem Div. United Merchants, Inc.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1986

PRODUCTION AND SALES & CAPTIVE USE
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	963	951	2.90
1978	1,122	1,103	3.00
1979	1,367	1,355	3.34
1980	1,165	1,147	3.11
1981	1,165	1,139	2.94
1982	998	976	2.66
1983	1,172	1,167	2.76
1984	1,199	1,189	2.63
1985	1,210	1,203	2.53
1986	1,271	1,266	2.87
Average Annual Growth			
1976-1986	4.4%	4.6%	

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

MELAMINE

MANUFACTURERS*

American Cyanamid Co.
American Hoechst Corp.
Borden Chemical Co., The
Chembond Corp.
Formica Corp.
Grifftex Chemicals, Inc.
Harborchem, Inc.
Interez, Inc.
Monsanto Co.
Perstorp Compounds, Inc.
Reichhold Chemicals, Inc.
Sterling Engineered Products

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1986.

PRODUCTION AND SALES & CAPTIVE USE
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	200	203	0.62
1978	202	196	0.53
1979	200	192	0.47
1980	167	166	0.45
1981	179	175	0.45
1982	158	155	0.42
1983	180	181	0.43
1984	210	197	0.44
1985	192	194	0.41
1986	173	191	0.43
Average Annual Growth			
1976-1986	-0.7%	0.5%	

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

UREA AND MELAMINE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1982	1983	1984	1985	1986
Textile treating & coating resins	NA	NA	23	17	21
Paper treating & coating resins	68	74	98	100	97
Bonding & adhesive resins for:					
Laminating	27	40	44	45	45
Plywood	64	63	59	57	60
Fibrous & granulated wood	759	918	944	955	1,029
Protective coatings	64	76	84	89	102
All other uses	132	155	134	134	102
Total	1,114	1,326	1,386	1,397	1,456

NA = Not Available
Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION OF UREA/MELAMINE BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	*	*	*	*	*
Packaging	44	45	32	30	33
Building/Construction	712	844	896	1,009	1,093
Electrical/Electronic	*	*	*	*	*
Furniture/Furnishings	148	*	*	43	37
Consumer & Institutional	*	*	*	116	*
Industrial/Machinery	—	—	—	—	—
Adhesives, Inks & Coatings	65	*	*	*	*
All Other	145	438	458	199	294
Exports	17	21	*	*	*
Total	1,131	1,348	1,386	1,397	1,457

*Included in all other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

UREA		MELAMINE	
Wiring devices	Buttons	Adhesives and bonding	Dinnerware
Toilet seats	Knobs	Buttons	Knobs
Handles	Adhesives and bonding	Handles	Ashtrays

DISTRIBUTION OF POLYURETHANE FOAM SALES AND USE BY MAJOR MARKET

(in millions of pounds)

	Quantity					% of Total				
	1981	1982	1983	1984	1985	1981	1982	1983	1984	1985
Transportation	268	248	301	330	400	15.4%	14.8%	15.8%	16.1%	18.8%
Flexible	227	216	269	300	350	13.0	12.9	14.1	14.6	16.4
Rigid	41	32	32	30	50	2.4	1.9	1.7	1.5	2.4
Packaging	77	77	85	90	80	4.4	4.6	4.3	4.4	3.8
Flexible	35	34	38	40	35	2.0	2.0	2.0	2.0	1.7
Rigid	42	43	47	50	45	2.4	2.6	2.3	2.4	2.1
Furniture/Furnishings	898	859	872	895	790	51.5	51.3	45.7	43.7	37.1
Flexible	882	838	856	875	775	50.6	49.8	44.8	42.7	36.4
Rigid	16	21	16	20	15	0.9	1.5	0.9	1.0	0.7
Building/Construction	328	328	379	400	430	18.8	19.6	19.9	19.5	20.2
Electrical/Electronic	76	80	87	100	125	4.4	4.8	4.6	4.8	5.8
All Other	97	82	185	235	305	5.5	4.9	9.7	11.5	14.3
Total	1,744	1,674	1,909	2,050	2,130	100.0%	100.0%	100.0%	100.0%	100.0%

POLYURETHANE FOAM—DOMESTIC SALES & CAPTIVE USE

(in millions of pounds)

	1981	1982	1983	1984	1985	Compound Growth Rate 1980–1985
Flexible and Semi-Flexible Foam						
Bedding (excluding sofa beds)	143	125	149	165	150	1.5%
Furniture	437	431	503	500	500	3.0
Packaging	35	34	38	40	35	8.8
Rug and Underlay	165	141	165	170	125	– 4.9
Textile Laminates	36	34	39	40	35	– 1.6
Transportation	227	216	269	300	350	7.6
Miscellaneous	40	43	35	45	60	0.7
Scrap	101	103	113	140	125	9.4
Total Flexible and Semi-Flexible Foam	1,184	1,127	1,311	1,400	1,380	3.3%
Rigid Foam						
Appliances	76	80	87	100	125	12.6%
Building Construction	328	328	379	400	430	6.4
Furniture	16	21	16	20	15	– 7.4
Marine Flotation	15	12	10	10	10	– 7.8
Packaging	42	43	47	50	45	5.8
Transportation	41	32	32	30	50	1.7
Miscellaneous	42	31	27	40	75	14.6
Total Rigid Foam	560	547	598	650	750	6.8%
Grand Total Foam	1,744	1,674	1,909	2,050	2,130	4.5%

Source: SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

[a] Industry Estimates

Note: Base Survey not available in 1986

ISOCYANATES

(in millions of pounds)

Year	PRODUCTION			SALES & CAPTIVE USE
	Total	TDI*	Other Isocyanates	Total
1982	1,042	547	495	1,052
1983	1,156	624	532	1,135
1984	1,331	680	651	1,312
1985	1,312	629	683	1,294
1986	1,346	654	692	1,349

*Toluene Diisocyanate (80/20 mixture)

POLYETHER POLYOLS

(in millions of pounds)

Year	Production	Sales & Captive Use
1982	1,111	1,209
1983	1,296	1,286
1984	1,347	1,305
1985	1,391	1,407
1986	1,452	1,453

POLYESTER POLYOLS

(in millions of pounds)

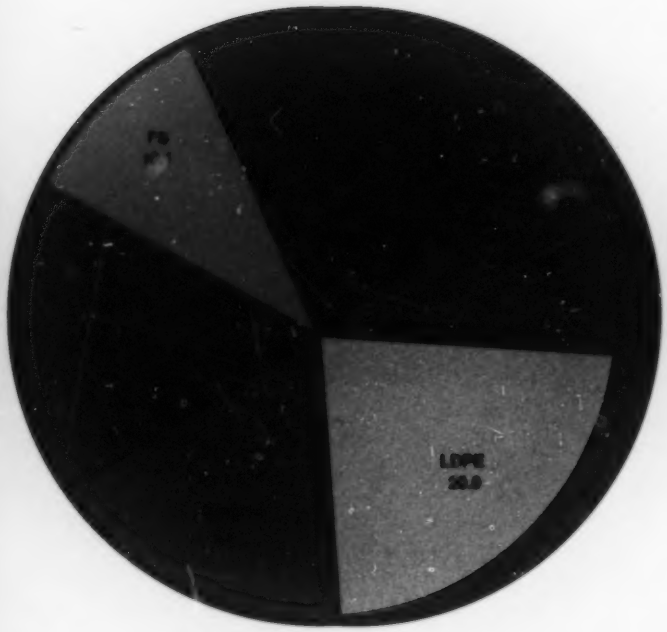
Year	Production	Sales & Captive Use
1982	28	28
1983	29	26
1984	26	26
1985	41	40
1986	47	46

PARTICIPATING COMPANIES—1986	Isocyanates	Polyether Polyols	Polyester Polyols
BASF Wyandotte Corp.	X	X	
Chemetic Systems			
Choate Chemical		X	
Dow Chemical U.S.A.	X	X	
E.I. duPont de Nemours & Co.		X	
ICI Polyurethanes	X		
Inolex Chemical			X
Mobay Chemical Corp.	X	X	X
Olin Corp.	X	X	
Owens-Corning Fiberglas Corp.		X	
Q.O. Chemical		X	
Ruco Div. Occidental Chemicals Corp.			X
Stepan Chemical Co.		X	
Sterling Engineered Products			X
Texaco, Inc.		X	
U.C.T., Inc.			
Union Carbide Corp.		X	X
Uniroyal Chemical Co.			X
Witco Chemical Co.		X	X

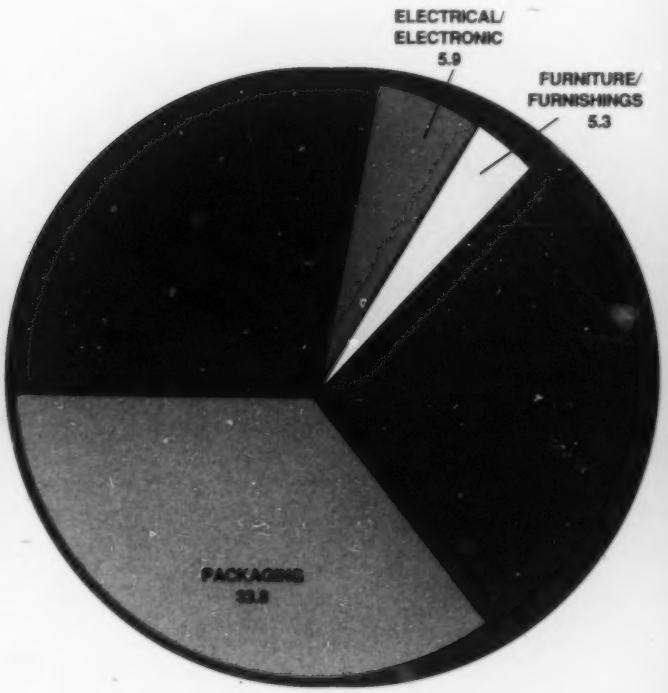
Source: Isocyanates and Polyols Reports, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

THERMOPLASTIC RESINS

Plastics which in their final state as finished articles are capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature and physical change.



1986 PERCENT OF THERMOPLASTIC SALES & CAPTIVE USE BY MATERIAL



1986 PERCENT OF THERMOPLASTIC SALES & CAPTIVE USE BY MAJOR MARKET

ABS AND SAN

MANUFACTURERS*

Borg Warner Chemicals
Dow Chemical U.S.A.
B.F. Goodrich Chemical Co.
W. R. Grace & Co.
Monsanto Company

*Those companies who participated in the SPI Monthly Statistical Report in 1986

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

	PRODUCTION		SALES & CAPTIVE USE	
YEAR	ABS	SAN	ABS	SAN
1977	1,069	115	1,057	113
1978	1,134	120	1,118	121
1979	1,191	124	1,183	126
1980	920	111	916	103
1981	916	107	900	105
1982	740	91	737	85
1983	NA	93	NA	91
1984	1,128	99	1,098	88
1985	1,028	87	1,016	84
1986	1,092	92	1,080	87
Average Annual Growth				
1976-1986	1.1%	-2.1%	1.5%	1.7%

NA = Not Available

PERCENT OF TOTAL U.S. SALES & CAPITAL USE

	ABS	SAN
1977	3.23	0.34
1978	3.04	0.33
1979	2.91	0.31
1980	2.48	0.28
1981	2.32	0.27
1982	2.01	0.23
1983	NA	0.22
1984	2.43	0.19
1985	2.14	0.18
1986	2.44	0.20

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney
NA = Not Available

ABS AND SAN

DISTRIBUTION OF ABS & SAN BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1982	1983[a]	1984	1985	1986
Transportation	156	267	267	269	285
Packaging	*	51	13	*	5
Building/Construction	124	197	*	134	133
Electrical/Electronic	203	246	269	241	261
Furniture/Furnishings	*	7	*	*	*
Consumer & Institutional	129	168	*	*	*
Industrial/Machinery	*	47	*	*	*
Adhesives, Inks & Coatings	—	27	*	*	*
All Other	153	175	638	456	484
Exports	57	144	*	*	*
Total	822	1,329	1,187	1,100	1,168

*Included in all other [a]Includes Other Styrene Based Polymers

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

ABS		SAN	
Household appliances	Business machines	Automotive trim	Boat hulls
Telephones	Refrigerator liners	Marine instruments	Solar collectors
Bath tubs	Sporting goods	Tractor components	Swimming pool components

ENGINEERING THERMOPLASTIC RESINS

The following resins are generally considered to be included in the category of engineering resins: fluoropolymers; polyimides and polyamide-imides; modified polyphenylene oxide; polyphenylene sulfide; thermoplastic polyester resin; polycarbonate; polysulfone; and acetal. Other materials which may be used in similar applications such as ABS, SAN, and nylon are mentioned elsewhere in Facts & Figures. Fluoropolymers, likewise, are mentioned elsewhere.

Engineering resins are characterized by a combination of high ratings for mechanical, thermal, electrical, and chemical properties. Fillers such as glass, carbon, metallic oxides, metallic powders, calcium carbonate, and silica products, and reinforcements such as fibrous glass, asbestos, carbon, and other inorganic and organic fibers are added to improve these properties.

TYPICAL APPLICATIONS

Acetal (AC)	Fasteners, knobs, bushings, bearings, faucets, valves, seat belt components, conveyor belts, zippers, disposable lighter bodies.
Fluoropolymers	Wire & cable jacketing, nonstick coatings, bearing pads, laminates.
Polycarbonate (PCO)	Microwave cookware, filter housings, bottles, lamp housings, drapery fixtures, safety glazing, nameplates, food processor bowls.
Polyphenylene Sulfide (PPS)	Pumps, hair dryers, small cooking appliances, automotive components.
Thermoplastic Polyester (TP)	Lighting, microwave cookware, bearings, beverage bottles, food containers, auto grilles, switches.
Polysulfone (PSO)	Food processing equipment, circuit boards, camera and watch cases, purification devices, connectors.
Modified Polyphenylene Oxide (PPO)	Personal computers, auto instrument panels, wheel covers, pump housings, radomes, fuse boxes, TV cabinetry.
Polyimide (PI)	Printed wiring boards, gears, electric motors, radomes, bearings.
Polyimide-imide (PAI)	Seals, valve train components, jet engine components, transmissions.

ENGINEERING THERMOPLASTIC RESINS

MANUFACTURING

KNOWN MANUFACTURERS	AC	PCO	PPS	TP	PSC	PPO	PI	PAI	FLUORO-POLYMERS
Allied				X					X
American Hoechst				X					
Amoco Chemical							X	X	
Celanese Engineering Resins	X			X					
Dow Chemical		X							
Dupont	X			X			X		X
Eastman Chemical				X					
GAF				X					
General Electric		X		X		X	X		
Goodyear				X					
ICI Americas									X
Mobay Chemical		X		X					
Pennwalt Corp.									X
Phillips Petroleum			X						
Union Carbide					X				

PRODUCTION AND SALES & CAPTIVE USE[1]

(in millions of pounds and dollars)

YEAR	PRODUCTION	SALES & CAPTIVE USE	SALES (EXCL. CAPTIVE & EXPORTS)	COMPOUND GROWTH RATE OF SALES & CAPTIVE USE	
1977	605	576	$486	1975–1985	6.9%
1978	648	639	579	1980–1985	5.4%
1979	729	709	699	1984–1985	– 6.0%
1980	673	645	715		
1981	676	633	806		
1982	569	596	755		
1983	731	781	979		
1984	878	892	1,148		
1985	834	839	1,107		

Source: SPI Committee on Resin Statistics as compiled by Ernst & Whinney

[1] Excludes thermoplastic polyester resins

DISTRIBUTION BY MAJOR MARKET[1]

(in millions of pounds)

MAJOR MARKET	1981	1982	1983	1984	1985
Transportation	76	80	123	136	140
Packaging	1	1	2	2	14
Building & Construction	96	82	76	101	79
Electrical/Electronic	211	192	275	305	250
Consumer/Institutional	37	45	82	90	28
Industrial/Machinery	58	52	75	88	37
Other	34	18	26	70	88
Exports	120	126	122	100	203
Total	633	596	781	892	839

Source: SPI Committee on Resin Statistics Annual Major Markets Survey & Industry estimates

[1] Excludes thermoplastic polyester

NOTE: SPI report not done in 1986

U.S. SALES OF FLUOROPOLYMER RESINS (GRANULAR TYPE ONLY)

(in thousands of pounds)

	1981	1982	1983	1984	1985
Virgin, First Quality	7,699	5,651	6,898	7,969	7,406
Filled Resin, including colors	3,265	2,283	3,131	4,061	4,006
Miscellaneous lubricants, release compounds, etc.[1]	3,503	2,493	2,524	3,034	3,549
Total	14,467	10,427	12,553	15,064	14,961

[1] Includes broad specification second quality.
Source: SPI's Fluoropolymers Division.

COMPOUND GROWTH RATE
1980–1985

Virgin, First Quality	0.2%
Filled resin, including colors	7.1%
Miscellaneous lubricants, release compounds, etc.	1.2%
Total	2.1%

SUPPLIERS OF GRANULAR PTFE RESINS

Allied Chemical Corp.
American Hoechst Corp.
Custom Compounding
E.I. duPont de Nemours & Co.
ICI Amer
LNP Corp. .tion
Mikro Technik
Montedison USA

TYPICAL APPLICATIONS

Plenum cable
Non-stick coatings
Wire ties
Chemical processing equipment
Filter housings
Valves
Electrical components
Tower packings
Heat-shrinkable tubing

NOTE: SPI report not done in 1986

HIGH DENSITY POLYETHYLENE

MANUFACTURING*

KNOWN MANUFACTURERS	ESTIMATED CAPACITY AS OF DECEMBER 31:[1] (millions of pounds) 1986	1987
Allied Chemical Co.	850	1,025
American Hoechst Corp.	250	250
Amoco Chemicals Corp.	340	340
Chevron Chemical Olefins	570	570
Dow Chemical U.S.A.	420	420
DuPont, E.I. de Nemours & Co.	900	900
Exxon Chemical USA[2]	0-600	0-600
Himont U.S.A.	30	30
Mobil Chemical Co.[2]	400-500	400-500
Phillips Chemical Co.	1,400	1,400
Soltex Polymers	950	1,000
Union Carbide Corp.[2]	400-1,600	600-1,800
U.S. Industrial Chemicals Co.	800-1,000	950-1,150
Total[2]	7,760-9,960	7,760-10,000

[1] Includes dual HDPE/LLDPE capacity

[2] Range takes into account swing capacity between HDPE/LLDPE

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1986

Source: Individual company figures are derived from published company reports, announcements to the trade press and other published trade sources

UTILIZATION RATE (%)	
1977	84.8
1978	85.8
1979	94.1
1980	74.4
1981	78.3
1982	76.5
1983	82.6
1984	82.9
1985	76.8
1986	81.1

PRODUCTION AND SALES & CAPTIVE USE
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	3,652	3,557	10.85
1978	4,201	4,165	11.31
1979	5,010	4,893	12.05
1980	4,405	4,394	11.91
1981	4,695	4,683	12.07
1982	4,928	5,024	13.71
1983	5,691	5,707	13.52
1984	6,085	5,949	13.16
1985	6,671	6,651	14.01
1986	7,182	7,028	15.91
Compound Growth Rate 1976-1986	8.6%	8.4%	

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

HIGH DENSITY POLYETHYLENE
DOMESTIC CONSUMPTION BY END-USE
(in millions of pounds)

END-USE	1982	1983	1984	1985	1986
Film (12 mils & below)	288	375	371	437	497
Sheet (over 12 mils)	64	76	121	140	177
Injection molding	1,102	1,188	1,191	1,538	1,550
Wire & cable	110	112	123	113	119
Extrusion coating	16	NA	NA	NA	NA
Blow molding	1,714	1,808	2,079	2,245	2,400
Pipe & conduit	395	471	473	478	444
Other extruded products	25	42	45	36	50
All other uses	633	634	850	787	866
Total	4,347	4,706	5,253	5,774	6,103

NA = Not Available
Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET
(in millions of pounds)

MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	49	121	*	183	232
Packaging	2,565	2,591	2,954	3,355	3,560
Building/Construction	441	518	513	546	522
Electrical/Electronic	142	123	149	153	147
Furniture/Furnishings	*	*	*	46	*
Consumer & Institutional	421	526	488	507	783
Industrial/Machinery	95	109	161	141	132
Adhesives, Inks & Coatings	*	*	*	—	*
All Other	634	718	988	843	728
Exports	677	1,001	696	877	924
Total	5,024	5,707	5,949	6,651	7,028

*Included in all other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Grocery bags
Bottles
Agricultural tanks
Florist tissue
Cables
Gasoline tanks
55-gal. drums
Shipping containers
Seating

LATEX MATERIALS

Latex materials (sometimes referred to as emulsion polymers) are dispersions of the plastic polymer particles in water. Developed in the laboratory in the early 1930's, the first successful product was a synthetic rubber latex, commercialized during World War II to supplement the short supply of natural rubber latex.

A great variety and profusion of emulsions are now in commercial production. The most important of the plastic latexes are copolymers of styrene and butadiene, homopolymers and copolymers of vinyl acetate, acrylates, and vinyl chloride, as well as emulsions of polyvinyl chloride, polyvinylidene chloride, and other specialties. Other co-monomers used include fumarate, maleate, and ethylene.

The non-plastic synthetic rubber latices, excluded from SPI statistics, are elastomers categorized as Styrene/Butadiene (high butadiene), Polybutadiene, Acrylonitrile/Butadiene, Chloroprene, and Butyl. There is a significant amount of inter-product competition, particularly among the plastic types, and further there is competition with the synthetic and natural rubber latices which historically have been used.

The major end-uses for these plastic latex materials lie in four areas: (1) Adhesives - primarily in the packaging, construction, and wood products areas; (2) Coatings - primarily as a vehicle in waterbased paints; (3) Paper - primarily as a clay coatings binder, but also used for saturating; and (4) Textiles - primarily as fabric finishes, sizes, back coats, and in fabric lamination and non-woven fiber bonding.

The emulsions and compounds are generally sold or used in relatively small batches (drums, tank trucks, and tank cars), and in many applications the emulsions are tailor-made to the end-use. There are thousands of end-users, some of whom polymerize for themselves, some of whom buy compounded material.

Each product sold has some unique characteristic desired in the end-use. For example, some adhesive resins should impart water resistance, fabric resins should be hard or soft depending on the type desired, and coatings resins should have good tint retention properties.

As a class these plastic emulsions have gained wide acceptance in the above mentioned end-uses for one or more of the following reasons:

- Water base (will meet the requirements of air pollution controls and regulations)
- Ease of clean-up
- Good adhesion to various substrates
- High pigment binding capacity
- Abrasion resistance and flexibility
- Uniform quality as compared with natural binders
- Good supply picture as compared with many of the natural binders
- Relative low cost versus binding efficiency
- Compatibility with existing technology and processes

STYRENE BUTADIENE & OTHER STYRENE BASED LATEXES

Significant producers are: Dow, General Tire & Rubber, Goodyear, W.R. Grace, Morton Industries, Polysar, Reichhold and Union Chemical.

PRODUCTION AND SALES & CAPTIVE USE
(thousands of pounds)

		SALES & CAPTIVE USE*				
Year	Production	Paper Treating	Textile Treating	Carpet Backing	All Other	Total
1982	510,160	24,211	12,829	199,461	267,760	504,261
1983	701,673	26,884	19,438	298,649	353,773	698,744
1984	745,109	24,400	15,483	315,811	393,302	748,996
1985	736,163	39,064	17,026	304,370	429,609	790,069
1986	823,305	55,722	20,438	315,581	475,572	867,313

* Data may not be comparable due to variations in participation

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

LOW DENSITY POLYETHYLENE

MANUFACTURING*

KNOWN MANUFACTURERS	ESTIMATED CAPACITY AS OF DECEMBER 31[1]: (millions of pounds) 1986	1987
Chevron Chemical Co.	900	900
Dow Chemical U.S.A.	1880	1,955
DuPont, E.I. de Nemours & Co.	700	700
Eastman Chemical Co.	620	620
El Paso Chemical Co.	400	400
Enron Chemical (formerly Norchem)	1210	—
Exxon Chemical U.S.A.[2]	1,000-1,180	1,000-1,180
Mobil Chemical Co.	700-875	700-875
Union Carbide Corp.[2]	1830-2130	1,830-2,130
U.S. Industrial Chemicals Co.	800-900	2,135
Total[2]	10,090-10,795	10,240-10,895

[1] Includes Linear Low Density [2] Range takes into account dual HDPE/LLDPE capacity not dedicated

* Those manufacturers who participated in the SPI monthly report in 1986

Source: Individual company figures are derived from published company reports, announcements to the trade press and other published trade sources

UTILIZATION RATE (%)	
1977	81.8
1978	88.9
1979	97.7
1980	86.1
1981	78.8
1982	80.2
1983	93.0
1984	82.3
1985	86.7
1986	88.9

PRODUCTION AND SALES & CAPTIVE USE
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	6,471	6,488	19.80
1978	7,111	7,147	19.41
1979	7,793	7,815	19.25
1980	7,291	7,467	20.24
1981	7,693	7,516	19.37
1982	7,503	7,687	20.98
1983	8,041	8,045	19.06
1984	8,413	8,416	18.61
1985	8,899	8,790	18.52
1986	8,903	8,799	19.91
Compound Growth Rate 1976-1986	4.4%	4.3%	

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

LOW DENSITY POLYETHYLENE
DOMESTIC CONSUMPTION BY END-USE
(in millions of pounds)

END-USE	1982	1983	1984	1985	1986
Film (12 mils & below)	4,209	4,628	4,689	4,777	4,787
Sheet (over 12 mils)	18	NA	NA	NA	NA
Injection molding	507	657	612	583	574
Wire & cable	278	310	368	337	336
Extrusion coating	544	573	640	649	678
Blow molding	42	42	43	47	39
Pipe & conduit	23	25	27	28	32
Other extruded products	46	92	95	103	112
All other uses	876	800	968	1,136	1,301*
Total	6,543	7,127	7,442	7,660	7,859

*Includes resellers and compounders
NA = Not Available
Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET
(in millions of pounds)

MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	*	*	*	*	*
Packaging	4,623	5,377	5,393	5,469	5,605
Building/Construction	225	226	313	327	213
Electrical/Electronic	345	374	430	403	421
Furniture/Furnishings	*	*	4	37	71
Consumer & Institutional	487	560	666	468	507
Industrial/Machinery	*	*	*	*	*
Adhesives, Inks & Coatings	46	*	67	111	231
All Other	817	589	569	844	812
Exports	1,144	919	974	1,131	939
Total	7,687	8,045	8,416	8,790	8,799

TYPICAL APPLICATIONS

Stretch wrap
Diaper liners
Household cling wrap
Squeeze bottles
Housewares
Lids
Closures
Pipe
Toys

NYLON

MANUFACTURING*

KNOWN MANUFACTURERS	ESTIMATED CAPACITY AS OF DECEMBER 31: (millions of pounds) 1986	1987
Allied Chemical Co.	100	110
ATOCHEM (formerly Rilsan)	31	31
BASF Corp..	20	20
Belding Chemical Industries	6	6
Celanese Engineering Resins Co.	40	40
Custom Resins, div. Bemis Co.	20	20
DuPont, E.I. de Nemours & Co.	230	230
Emser Industries	10	10
Monsanto Company	80	80
Nylon Corp. of America	22	22
Shakespeare Co.	4	4
Wellman, Inc.	24	24
Total	587	597

*Those manufacturers who participated in the SPI Monthly Statistical Report in1986

Source: Individual company figures are derived from published company reports, announcements to the trade press and other published trade sources

UTILIZATION RATE (%)	
1977	70.8
1978	74.5
1979	79.8
1980	64.0
1981	70.6
1982	53.1
1983	74.7
1984	77.5
1985	70.9
1986	79.2

PRODUCTION AND SALES & CAPTIVE USE
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	254	250	0.76
1978	275	278	0.76
1979	327	315	0.78
1980	274	271	0.73
1981	312	288	0.74
1982	228	247	0.67
1983	321	329	0.78
1984	396	389	0.86
1985	399	403	0.85
1986	465	443	1.00
COMPOUND GROWTH RATE			
1976-1986	6.5%	7.2%	

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

NYLON
DOMESTIC CONSUMPTION BY END-USE

(in thousands of pounds)

END-USE	1982	1983	1984	1985	1986
Automotive and truck	69,909	109,949	147,500	166,232	167,741
Electrical and Electronic[1]	28,870	36,144	45,247	42,286	46,996
Appliances	6,847	6,804	6,752	7,559	6,254
Film and Coating	31,879	40,156	43,014	41,698	46,459
Wire and Cable	15,898	18,733	20,913	21,093	22,269
Monofilament	10,126	15,184	15,283	16,006	20,753
Consumer[2]	14,967	20,187	19,547	20,930	24,604
Industrial/Machinery	13,733	27,853	34,111	31,931	26,600
Others	38,296	30,043	30,978	30,739	41,761
Total	230,525	305,053	363,345	378,474	403,437

[1]Includes electrical and electronic applications not assignable to automotive and truck or appliance markets
[2]Includes such items as housewares, brushes, combs, sporting goods, cameras and toys
Source: SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	74	109	156	180	192
Packaging	33	40	38	*	*
Building/Construction	*	*	*	*	*
Electrical/Electronic	50	60	73	67	71
Furniture/Furnishings	*	9	6	5	6
Consumer & Institutional	13	*	*	*	31
Industrial/Machinery	21	28	38	32	32
Adhesives, Inks & Coatings	*	*	*	*	*
All Others	38	59	52	95	72
Exports	18	24	26	24	39
Total	247	329	389	403	443

*Included in all other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

- Electrical connectors
- Fender extensions
- Brush bristles
- Wire jackets
- Power tool housings
- Fishing line
- Emission cannisters
- Cooking bags
- Sutures

POLYPROPYLENE

MANUFACTURING*

KNOWN MANUFACTURERS	ESTIMATED CAPACITY AS OF DECEMBER 31: (millions of pounds) 1986	1987
Amoco Chemicals Co.	1,000	1,000
Aristech Chemical Co.	—	515
Eastman Chemical Products, Inc.	140	140
El Paso Chemical Co.	350	350
Exxon Chemical U.S.A.	550	690
Fina Oil & Chemical	450	450
Himont U.S.A.	1,425	1,500
Norchem	240	240
Phillips Petroleum Company	250	250
Shell Chemical Company	800	800
Soltex Polymer Corp.	260	300
USS Chemicals Co.	500	—
Total	5,965	6,235

Source: Individual company figures are derived from published company reports, announcements to the trade press and other published trade sources

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1986

UTILIZATION RATE (%)	
1977	82.5
1978	66.8
1979	76.3
1980	70.2
1981	78.2
1982	68.3
1983	84.1
1984	87.8
1985	86.1
1986	97.4

PRODUCTION AND SALES & CAPTIVE USE
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	2,747	2,698	8.23
1978	3,074	3,055	8.30
1979	3,841	3,894	9.59
1980	3,648	3,714	10.07
1981	3,955	3,888	10.02
1982	3,477	3,623	9.89
1983	4,434	4,464	10.58
1984	4,940	4,816	10.65
1985	5,139	5,275	11.11
1986	5,812	5,824	13.18
COMPOUND GROWTH RATE			
1976-1986	7.8%	8.7%	

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYPROPYLENE
DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1982	1983	1984	1985	1986
Injection molding, total	1,073	1,232	1,290	1,274	1,289
Appliances	72	96	121	114	127
Consumer products	273	301	292	310	311
Rigid packaging	291	351	360	387	430
Transportation	225	293	316	340	308
All other injection molding	212	191	201	123	113
Blow molding	68	90	105	105	106
Film (10 mils & below)	290	364	401	389	498
Sheet	19	33	52	44	39
Other extruded products (including wire & cable, pipe & conduit, and extrusion coating)	93	106	112	89	98
Fiber & filaments	866	1,221	1,338	1,433	1,516
All other uses	476	618	736	1,066	1,148
Total	2,885	3,664	4,034	4,400	4,694

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	199	293	233	230	237
Packaging	757	845	901	1,000	1,128
Building/Construction	31	22	36	*	*
Electrical/Electronic	161	242	289	273	277
Furniture/Furnishings	772	983	1,123	1,119	1,103
Consumer & Institutional	421	580	624	621	732
Industrial/Machinery	*	*	*	11	*
Adhesives, Inks & Coatings	*	*	*	*	*
All Other	545	699	828	1,146	1,217
Exports	737	800	782	875	1,130
Total	3,623	4,464	4,816	5,275	5,824

*Included in all other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Retort pouches
Tobacco wrap
Bottles
Battery cases
Carpet backing
Threaded caps
Filter plates
Toys
Microwave oven containers

POLYSTYRENE

MANUFACTURING*

KNOWN MANUFACTURERS	ESTIMATED CAPACITY AS OF DECEMBER 31: (millions of pounds) 1986	1987
A & E Plastics	50	50
Amoco Chemicals Corp.	400	400
ARCO Chemicals Co.	500	500
Asoma Polymers	45	45
BASF Wyandotte Corp.	180	180
Chevron Chemical Co.	400	400
Dart Polymers	40	40
Dow Chemical Corp.	850	850
Fina Oil & Chemical	400	400
Georgia Pacific	60	60
Huntsman Chemical Co.	1,000	963
Kama Corp	40	40
Mobil Chemical Corp.	375	375
Monsanto Company	655	—
Polysar, Inc.	300	700
Texstyrene Plastic Co.	90	90
Vititek	5	5
Total	5,390	5,098

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1986

Source: Individual company figures are derived from published company reports, announcements to the trade press and other published trade sources

UTILIZATION RATE (%)	
1977	66.7
1978	75.9
1979	77.0
1980	67.1
1981	70.2
1982	61.7
1983	68.7
1984	70.0
1985	75.0
1986	87.7

PRODUCTION AND SALES & CAPTIVE USE
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	3,446	3,557	10.85
1978	3,823	3,870	10.51
1979	4,005	3,997	9.84
1980	3,521	3,518	9.53
1981	3,621	3,604	9.29
1982	3,191	3,200	8.73
1983	3,567	3,606	8.54
1984	3,838	3,836	8.48
1985	4,054	4,108	8.65
1986	4,470	4,463	10.10
COMPOUND GROWTH RATE			
1976-1986	3.4%	3.5%	

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYSTYRENE
DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1982	1983	1984	1985	1986
Straight Polystyrene[a]	1,669	1,811	1,959	2,078	2,341
Rubber-Modified Polystyrene[a]	1,531	1,718	1,776	1,946	2,121
Total	3,200	3,529	3,735	4,024	4,462
Molding	1,368	1,516	1,436	1,403	1,540
Extrusion	1,060	1,238	1,468	1,737	1,966
Expandable Polystyrene Beads	426	440	487	521	497
All Other Uses	251	335	344	363	345
Total Domestic	3,105	3,529	3,735	4,024	4,348

[a]Includes exports 1981–1982
Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	4	12	*	*	*
Packaging	1,288	1,486	1,540	1,292	1,360
Building/Construction	289	294	385	449	418
Electrical/Electronic	311	307	351	309	360
Furniture/Furnishings	39	47	26	47	47
Consumer & Institutional	745	820	754	1,090	1,296
Industrial/Machinery	*	*	*	*	*
Adhesives, Inks & Coatings	*	*	—	*	*
All Other	429	563	679	837	868
Exports	95	77	101	84	114
Total	3,200	3,606	3,836	4,108	4,463

*Included in all other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Disposable serviceware
Pallets
Trays
Video cassettes
Appliance parts
Roofing insulation
Business machines
Syringes
Egg cartons

POLYVINYL CHLORIDE

MANUFACTURING*

KNOWN MANUFACTURERS	ESTIMATED CAPACITY AS OF DECEMBER 31: (millions of pounds) 1986	1987
Air Products & Chemicals	500	500
Borden Chemical Company, The	800	800
Certain-Teed Products Corp.	220	220
Formosa Plastics	935	935
Georgia-Gulf Corp.	850	850
B.F. Goodrich Chemical Company, The	1,800	1,650
Goodyear Tire & Rubber Company, The	100	110
Keysor-Century Corp.	50	50
Occidental Chemical Co.	1,470	1,520
Shintech, Inc.	950	950
Union Carbide Corp.	125	125
Vista Chemicals	715	715
Vygen	100	100
Total	8,615	8,525

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1986

Source: Individual company figures are derived from published company reports, announcements to the trade press and other published trade sources

UTILIZATION RATE (%)	
1977	82.8
1978	90.8
1979	86.3
1980	76.8
1981	75.8
1982	72.1
1983	79.2
1984	81.3
1985	80.0
1986	84.2

TYPICAL APPLICATIONS

Food wrap
Flooring
Siding
Pipe
Wall covering
Coatings
Upholstery
Garden hose
Shower curtains

PRODUCTION AND SALES & CAPTIVE USE
(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	
		Volume	Total % of U.S. Sales
1977	5,253	5,232	15.97
1978	5,723	5,810	15.78
1979	6,119	6,138	15.12
1980	5,470	5,407	14.65
1981	5,707	5,601	14.44
1982	5,326	5,455	14.89
1983	6,066	6,152	14.57
1984	6,760	6,798	15.03
1985	6,772	6,720	14.16
1986	7,256	7,412	16.78
Compound Growth Rate			
1976-1986	4.4%	4.6%	

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYVINYL CHLORIDE
DOMESTIC CONSUMPTION BY END-USE
(in millions of pounds)

End-use	1982	1983	1984	1985	1986
Calendering, total	594	682	720	690	716
Flooring	149	160	173	161	163
Textile	64	105	91	71	79
All other calendering	381	417	456	458	474
Coating, total	267	361	350	303	330
Flooring	99	149	146	125	144
Textile & paper coating	87	119	107	93	97
Protective coatings	38	45	43	46	48
Adhesives & all other coatings	43	48	54	39	41
Extrusion, total	3,129	3,496	4,330	4,481	4,898
Wire & cable	328	350	411	455	419
Film & sheet	312	309	350	226	258
Rigid pipe & tubing (except fittings)	2,014	2,273	2,901	2,809	3,165
All other extrusions	475	564	668	991	530
Siding, siding accessories & mobile homes & skirts	NA	NA	NA	NA	526
Molding, total	364	430	464	465	495
Bottles	103	166	186	163	188
Sound records	112	80	75	68	54
Fittings (rigid pipe & tubing)	99	106	122	160	141
All other molding	50	78	81	74	112
Paste processes (except coating), total	172	166	169	156	156
Plastisol formulation	85	96	93	77	76
All other	87	70	76	79	80
Resellers & Compounders	147	203	167	101	332
All other uses	217	280	220	233	115
Grand total	4,890	5,618	6,420	6,429	7,042

NA = Not Available
Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET
(in millions of pounds)

Major Market	1982	1983	1984	1985	1986
Transportation	123	150	163	141	149
Packaging	450	546	619	572	497
Building/Construction	2,902	3,329	4,134	4,198	4,711
Electrical/Electronic	467	386	398	479	478
Furniture/Furnishings	236	289	242	310	380
Consumer & Institutional	356	293	290	230	277
Industrial/Machinery	*	20	19	30	17
Adhesives, Inks & Coatings	*	77	108	89	83
All Other	355	528	447	379	450
Exports	566	534	378	292	370
Total	5,455	6,152	6,798	6,720	7,412

*Included in all other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

POLYVINYL ACETATE

Polyvinyl acetate is produced by the emulsion polymerization of vinyl acetate to yield a water emulsion with a solids content of 50-55%. Commercial exploitation of this polymer began in the early 1930's, although its discovery dates from the early 1900's. Early production of the resin was primarily as a homopolymer, but more recently resin properties have been changed by including comonomers as n-butyl acrylate, 2-ethylhexyl acrylate, ethylene, dibutylmaleate, and dibutyl fumarate. Because of the large number of polyvinyl acetate producers, the numerous copolymers included and the variety of physical forms, polyvinyl acetate production is reported to SPI in terms of vinyl acetate monomer sold to or used by the polymerizer.

Polyvinyl acetate resins are primarily used in aqueous emulsions and find utility in adhesives, paints, textile finishes, and paper coating applications. A typical example of a polyvinyl acetate emulsion is the "white glue" used in many homes and schools.

There are more than 50 producers of polyvinyl acetate, supplied with monomer by such companies as Air Products & Chemicals, Borden, Celanese Chemical, H.B. Fuller, W.R. Grace, Monsanto, National Starch, Reichhold Chemicals, Rohm & Haas, Union Carbide, Union Chemical, and U.S. Industrial Chemicals.

SALES AND CAPTIVE USE OF VINYL ACETATE MONOMER FOR POLYVINYL ACETATE

(thousands of pounds)

Year	Emulsion Paint	Adhesives	Paper	Textile	Non-woven Binders	Others	Export	Total
1982	163,470	234,994	94,185	17,250	25,700	26,143	6,081	567,823
1983	210,553	273,751	117,330	22,601	31,212	27,542	5,867	688,856
1984	203,282	275,002	119,528	25,924	30,896	28,767	6,976	690,375
1985	204,497	262,437	110,969	31,964	NA	58,185	6,124	674,176
1986	233,730	254,056	110,001	32,027	NA	56,340	3,964	690,118

COMPOUND GROWTH RATE TOTAL SALES & CAPTIVE USE

1984–1985	-0.1%
1985-1986	2.4%

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

OTHER VINYL RESINS

Vinyl resins included in this category are polyvinyl butyral, polyvinyl formal, and polyvinylidene chloride and their respective copolymers containing at least 50% of the base resin.

Polyvinyl butyral and polyvinyl formal are prepared by reacting polyvinyl alcohol with butyraldhyde or formaldehyde in the presence of a strong mineral acid. There are many grades of these products in use, differing in degree of hydroxyl substitution and molecular weight. The largest end of polyvinyl butyral is as the adhesive film in the lamination of auto safety glass. The major use of polyvinyl formal is in magnet wire coatings.

Polyvinylidene chloride is prepared by suspension or emulsion polymerization of vinylidene chloride. It finds major application as a film or as a coating on flexible substrates for packaging food products where oxygen impermeability and oil resistance are important.

Producers of these vinyl resins include Dow, DuPont, B.F. Goodrich, W.R. Grace, Monsanto, Morton Industries, Rohm and Haas, Union Carbide and Union Chemical.

Producers of these vinyl resins include Dow, DuPont, W.R. Grace, Monsanto, Morton Industries, Rohm and Haas, and Unocal.

PRODUCTION AND SALES & CAPTIVE USE
(thousands of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1982	177,225	166,695
1983	185,558	177,844
1984	187,209	186,619
1985	189,699	191,437
1986	194,924	180,357

GROWTH RATE OF SALES & CAPTIVE USE	
1984–1985	2.6%
1985-1986	-5.8%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DOMESTIC SALES & USE OF SELECTED THERMOPLASTICS BY PROCESS GRADE

(millions of pounds)

MATERIAL/YEAR	TOTAL	INJECTION MOLDING	EXTRUSION	BLOW MOLDING	OTHER
Grand Total					
1982	23,259	4,979	11,665	2,383	4,232
1983	26,546	5,778	13,407	2,620	4,741
1984	29,007	5,849	14,918	2,948	5,292
1985	30,407	6,052	15,526	3,182	5,647
1986	N.C.	N.C.	N.C.	N.C.	N.C.
LD Polyethylene					
1982	6,543	507	5,118	42	876
1983	7,127	657	5,628	42	800
1984	7,442	612	5,819	43	968
1985	7,660	583	5,894	47	1,136
1986	7,859	575	6,487	39	758
Growth Rate					
1981-1986	3.7%	2.1%	4.9%	-8.3%	-2.7%
HD Polyethylene					
1982	4,347	1,102	898	1,714	633
1983	4,706	1,188	1,076	1,808	634
1984	5,253	1,191	1,133	2,079	850
1985	5,774	1,538	1,204	2,245	787
1986	6,103	1,550	1,275	2,400	878
Growth Rate					
1981-1986	7.6%	9.2%	7.1%	7.1%	7.1%
Polypropylene					
1982	2,885	1,073	1,268	68	476
1983	3,664	1,232	1,724	90	618
1984	4,034	1,290	1,903	105	736
1985	4,400	1,274	1,955	105	1,066
1986	4,694	1,289	2,152	106	1,147
Growth Rate					
1981 - 1986	7.9%	0.6%	7.8%	10.3%	22.0%
A B S[a]					
1982	689	430	111	—	148
1983	900	560	145	—	195
1984	1,000	600	150	—	250
1985	900	575	125	—	200
1986	1,080	NA	NA	—	NA
Growth Rate					
1981 - 1986	4.9%	—	—	—	—

[a]ABS estimated 1983–1985

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

N.C. = Not comparable, reporting changes in 1986

NA = Not Available

DOMESTIC SALES & USE OF SELECTED THERMOPLASTICS BY PROCESS GRADE (Cont'd)

(millions of pounds)

MATERIAL/YEAR	TOTAL	INJECTION MOLDING	EXTRUSION	BLOW MOLDING	OTHER
Polystyrene					
1982	3,105	1,368	1,060	—	677
1983	3,529	1,516	1,238	—	775
1984	3,735	1,436	1,468	—	831
1985	4,024	1,403	1,737	—	884
1986	4,348	1,540	1,966	—	842
Growth Rate					
1981-1986	4.7%	-1.2%	11.4%	—	4.6%
Nylon					
1982	229	138	71	—	20
1983	305	198	85	—	22
1984	363	243	95	—	25
1985	378	251	100	—	27
1986	403	266	112	—	25
Growth Rate					
1981-1986	8.3%	8.3%	8.0%	—	9.3%
Thermoplastic Polyester[b]					
1982	571	100	10	456	5
1983	697	163	15	514	5
1984	760	200	20	535	5
1985	842	190	25	622	5
1986	NA	NA	NA	NA	NA
Growth Rate					
1980–1985	11.8%	7.4%	43%	13.2%	60%
P V C					
1982	4,890	261	3,129	103	1,397
1983	5,618	264	3,496	166	1,692
1984	6,420	277	4,330	186	1,627
1985	6,429	228	4,481	163	1,557
1986	7,042	306	4,899	188	1,649
Growth Rate					
1981-1986	6.4%	18.0%	9.2%	15.3%	0.1%

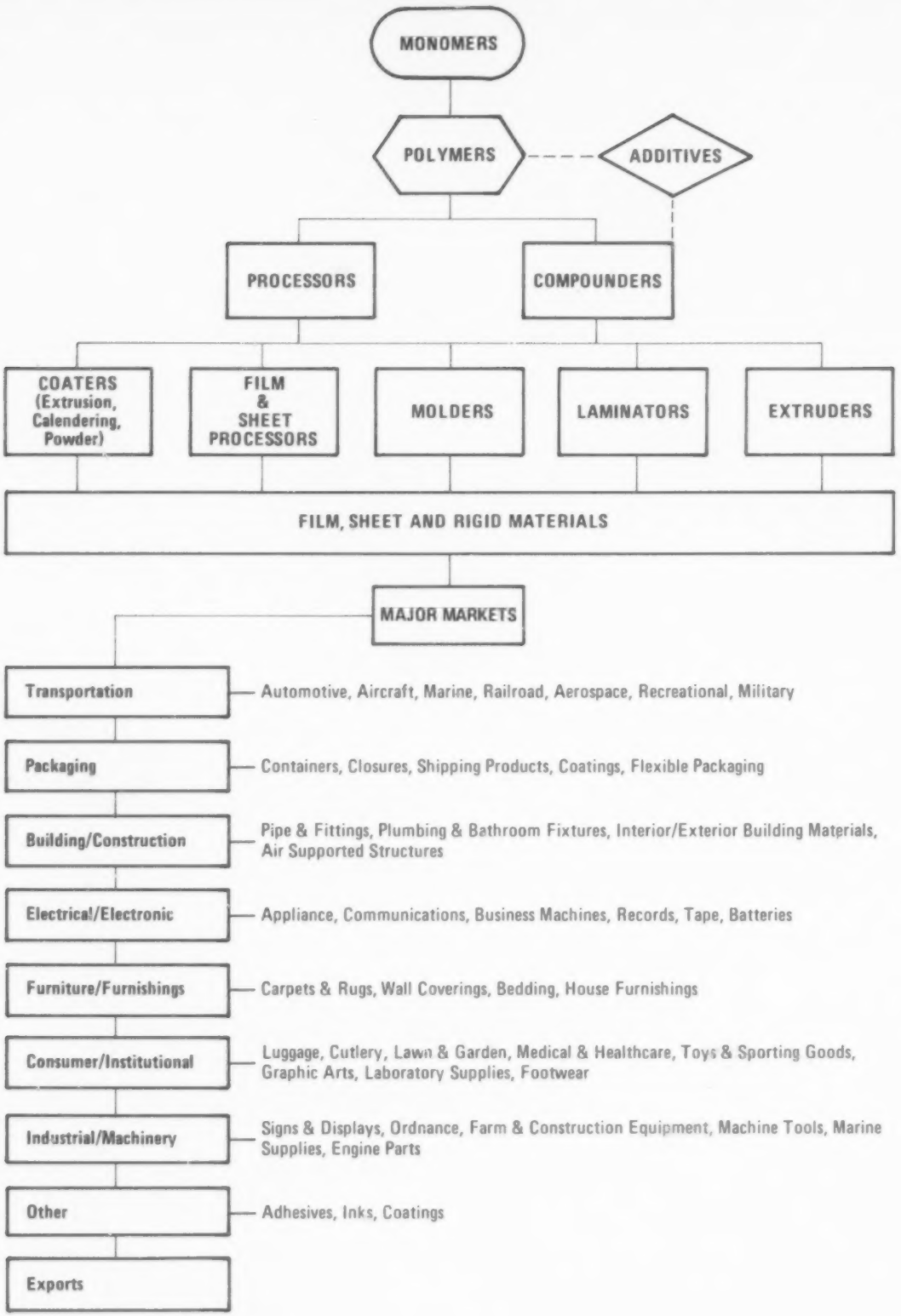
[b]Thermoplastic Polyester estimated 1983–1985

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

FABRICATED PLASTIC PRODUCTS

FLOW CHART: FROM RAW MATERIAL TO FINAL PRODUCT



Source: SPI, Committee on Resin Statistics, *Major Markets Manual*

REINFORCED PLASTICS

The combination of thermosetting unsaturated polyester resins with glass fiber accounts for the bulk ot reinforced plastics products. Phenolics, vinyl esters, epoxies and fumarate resins bring thermosets' share of the market to almost 90%. The thermoplastics which account for the remainder, in general relative importance, are polyolefins, nylon, polycarbonate, styrenics, and polyvinyl chloride.

Random glass fibers are the volume reinforcement, but beads, flake, and woven mat and roving are other forms in which the glass may be used. For very high-performance or unique applications such as required in aerospace parts, or sporting goods shafts, carbon and graphite or certain synthetic fibers have a growing use experience. By weight the reinforcement is usually 25-35%, but 50% is not unusual in spray-up or press-molded materials.

Thermoset materials have been the choice for impact-strength, higher resistance to heat distortion, and resistance to corrosive environments. Thermoplastics are developing where large runs of uniform parts are a requirement, and where relatively smaller size of the parts makes processing feasible. In the last two years the reinforcement of foamed parts has become a reality in several markets.

Reinforced plastics production at the outset, during World War II, was almost entirely for military use such as in radomes. In recent years the marine market has dominated consumption, but even though its projected growth is 75% over the next five years it will probably soon take second place to transportation. The use of RP in automobiles could double over the next four years. The other high-volume growth market in the immediate future is chemical-resistance and pipeline application. All of the use categories for reinforced plastics are slated for faster growth than the economy generally.

The reinforced plastics industry enjoys a high level of technical activity because of the engineered nature of its products, and the relatively high value-added nature of the finished product. The search for new applications is vigorous, while new levels of performance in existing uses are continually being refined. Environmental and health concerns about styrene monomer, as well as continued demands of fire-retardant and non-toxic materials, suggest that research on basic resin characteristics will also continue.

The structure of the reinforced plastics industry has stabilized in recent years. Several materials suppliers have, in the pattern of other domestic industries, "integrated forward" by acquiring or developing fabrication divisions whch specialize in a given manufacturing process or market, such as panels for light construction, corrosion-resistant equipment, or sanitaryware. More common, however, has been the development by large corporations identified with a given market, such as industrial pipe, automotive parts, or marine equipment, of a "captive" reinforced plastics operation which complements or replaces their metal or woodworking manufacturing. In the last decade custom molders have attempted to stabilize their role by selecting to produce several types of parts which they handle especially well, but spreading these selections over several market areas to minimize uneven business cycles. There have, of course, emerged large and small manufacturing companies who independently specialize in a given process or product. To complete the picture of the RP industry's diversity, we must mention that there is still room for the inventor/entrepreneur and, at the other end of the development process, there continues to be a considerable degree of university and laboratory research.

REINFORCED PLASTICS SHIPMENTS BY MARKET

(BOTH THERMOSET & THERMOPLASTIC RESINS)

	SHIPMENTS (in millions of pounds)						
MARKETS	**1981**	**1982**	**1983**	**1984**	**1985[1]**	**1986[1]**	**1987[2]**
Aircraft & Aerospace	28	22	25	29	32	37	40
Appliances & Equipment	117	82	106	123	133	136	141
Construction	317	312	400	430	445	456	464
Consumer Goods	115	84	128	143	142	149	152
Corrosion-Resistant Products	275	235	288	310	295	291	300
Electrical Rods, Tubes, Parts	178	140	170	189	191	201	208
Marine & Marine Accessories	290	230	276	309	335	340	351
Land Transportation	445	359	458	540	563	585	608
Miscellaneous	75	64	72	80	82	83	85
Total	1,840	1,528	1,923	2,153	2,218	2,278	2,349

[1] = estimate
[2] = forecast

Source: Reinforced Plastics/Composites Institute, SPI

HIGH DENSITY POLYETHYLENE—SELECTED END-USES
(in millions of pounds)

	1982	1983	1984	1985	1986
FILM	281	370	361	NA	491
Millinary/Merchandising Bags	121	165	168	NA	173
Food Packaging	64	101	76	NA	NA
All Other	96	104	117	NA	318
INJECTION MOLDING	1,071	1,175	1,129	NA	1,562
Industrial and Shipping Pails[1]	259	232	324	NA	433
Housewares[2]	123	175	105	NA	166
Crates and Totes[3]	108	146	112	NA	156
Toys	74	111	63	NA	66
Aerosol Overcaps, caps, closures	66	70	91	NA	70
Food Tubs or Containers	172	174	238	NA	176
All Other	269	267	196	NA	495
BLOW MOLDING	1,603	1,733	2,027	NA	2,406
Liquid Food Bottles	679	698	687	NA	802
Household Chemicals	560	600	657	NA	813
Industrial Drums	69	90	163	NA	171
Pharmaceuticals, Cosmetics & Toiletries	106	127	113	NA	174
All Other	189	218	407	NA	446
ROTOMOLDING	NA	64	NA	NA	NA
PIPE AND CONDUIT	390	465	469	NA	453
Corrugated	165	195	138	NA	143
Gas Distribution	79	74	126	NA	120
All Other	146	196	205	NA	190

NA = Not Available

[1] 5 gallons or less

[2] Includes household pails

[3] Includes beverage cases

Source: SPI, Committee on Resin Statistics as compiled by Ernst & Whinney

LOW DENSITY POLYETHYLENE—SELECTED END USES

(in millions of pounds)

	1982	1983	1984	1985	1986
PACKAGING FILM	2,669	3,155	2,955	NA	3,027
Food Packaging	933	1,092	874	NA	980
Produce	192	146	74	NA	165
Bakery	292	256	243	NA	356
All Other	449	690	557	NA	459
Non-Food Packaging	1,446	1,692	1,705	NA	1,674
Industrial Liners	819	966	949	NA	696
Shipping Sacks	138	141	219	NA	262
All Other	489	585	537	NA	716
Pallet Shrink Film	121	107	72	NA	98
All Other Shrink Film	55	81	69	NA	33
Stretch Film	114	183	235	NA	243
Non-Packaging Film	1,518	1,455	1,640	NA	1,724
Trash Bags	993	881	902	NA	976
Construction and Agriculture	190	164	194	NA	119
Disposable Diapers	NA	NA	NA	NA	34
All Other	335	410	544	NA	495
INJECTION MOLDING	471	578	555	NA	581
Lids	130	160	140	NA	148
Toys and Novelties	25	31	23	NA	31
Housewares	142	221	223	NA	221
All Other	174	166	169	NA	181
EXTRUSION COATING	529	559	637	NA	708
Paperboard	292	338	384	NA	367
All Other	237	221	253	NA	341
Wire & Cable	NA	NA	NA	NA	338
ROTOMOLDING RESINS	NA	23	56	NA	89

NA = Not Available
Source: SPI, Committee on Resin Statistics as compiled by Ernst & Whinney

PLASTIC BOTTLES: SHIPMENTS

(in millions of units)

BY MARKET	1983	1984[R]	1985	1986
Household Chemicals	2,899	2,905	2,942	2,990
Industrial Chemical	387	405	429	460
Automotive & Marine	334	394	416	455
Toiletries & Cosmetics	2,405	2,485	2,532	2,595
Medicinal & Health	2,335	2,365	2,425	2,475
Food				
Milk	2,659	2,700	2,735	2,755
Other food	798	890	960	1,040
Beverages				
Carbonated Soft Drinks	2,942	3,342	4,600	5,900
Other beverages	909	1,014	1,080	1,150
Other	779	820	835	860
Total	16,447	17,320	18,954	20,680

EXPLANATION OF TERMS

Household Chemicals— Bleach, dishwashing, laundry, and other detergents; fabric softeners; blow and drain cleaners; dry cleansers; floor care products; soaps (including medicated); window cleaners; air fresheners; household pesticides and garden chemicals; household adhesives; waxes and polishes (including car polish); car wax, wax and polish remover, etc.

Industrial, Agricultural and Specialty Chemicals— Agricultural, industrial, and institutional chemical and cleaning products; photographic chemicals; battery acid; paint and varnish supplies, etc.

Toiletries and Cosmetics— Shampoos and other hair grooming products; talcs and powders; hand, face, and body lotions and ointments; shaving preparations; bath products; perfumes, toilet water, and colognes; personal deodorant, etc.

Medicinal and Health— Oral antiseptics and mouthwashes; laxatives; pharmaceutical lotions, creams, and ointments; pain relievers; vitamins; rubbing alcohols; antacids, etc.

Food and Beverages— Milk; carbonated beverages; noncarbonated beverages such as juices, water, cider, etc.; distilled spirits and other alcoholic beverages; edible oil; and all other food items.

Automotive and Marine— Antifreeze; motor oil; lubricants; defrosters; windshield cleaners; hydraulic fluids; additives, etc.

CONSUMPTION OF PLASTICS BOTTLE MATERIALS

(in millions of pounds)

BY MATERIAL	1983[R]	1984[R]	1985	1986
LD Polyethylene	58.1	60.4	63.8	64.0
HD Polyethylene	1,248.5	1,335.5	1,420.0	1,435.0
Poly Vinyl Chloride	118.2	131.3	145.0	148.0
Polypropylene	57.0	63.5	84.0	88.0
Polyethylene Terephthalate	420.5	452.0	480.0	660.0
Polystyrene & Other	6.3	8.1	9.0	8.5
Total	1,908.6	2,050.8	2,201.8	2,403.5

1 = Estimate
R = Revised
Source: U.S. Department of Commerce: Census & ITA

PLUMBING FIXTURES: SHIPMENTS

(Thousands of units)

LAVATORIES

	Total	Vitreous China	Cast Iron	Steel	Plastics[1]
1982	3,562	1,887	506	854	315
1983	5,100	2,514	519	1,470	597
1984	7,252	2,572	632	1,768	2,280
1985	7,598	2,770	602	1,860	2,366
1986	12,257	719	626	5,142	5,770

BATHTUBS

	Total	Cast Iron	Steel	Plastics
1982	2,399	545	809	1,045
1983	3,418	551	1,292	1,575
1984	3,943	595	1,280	2,068
1985	4,273	585	1,407	2,281
1986	34,621	129	18,470	16,022

SHOWER STALLS, INC. RECEPTORS

	Total	Metals	Plastics
1982	312	9	303
1983	424	12	412
1984	605	10	595
1985	707	39	668
1986	NA	NA	5,634

[1]Includes concrete and other nonmetals

NA= Not Available

Source: U.S. Dept. of Commerce, Bureau of the Census

MAJOR MARKETS

DEFINITIONS

The primary product groups for each Major Market category are listed below:

A. TRANSPORTATION

Motor Vehicles and Parts: including autos, trucks, buses, motorcycles, and bicycles.
All Other: including railroad equipment, travel trailers, campers, golf carts, snowmobiles, aircraft, military vehicles, ships, boats and recreational vehicles.

B. PACKAGING

Bottles, Jars, Vials
Food Containers: excluding disposable cups
Flexible Packaging: including household and institutional refuse bags and film
All Other: including tubes, tape, strapping, drums, caps, baskets, trays, boxes, pallets, shipping crates, pails, buckets, shipping cases, blister and bubble containers.

C. BUILDING AND CONSTRUCTION

Pipe, Conduit and Fittings: including drainage, irrigation, plumbing fixtures, septic tanks
Building Material for all Structures: including siding, flooring, and insulation materials
All Other: including panels, doors, windows, skylights, bathroom units, gratings and railings.

D. ELECTRICAL AND ELECTRONIC

Home and Industrial Appliances: including electrical industrial equipment, wire and cable coverings, communications equipment
Electronic Components: including resistors, magnetic tape, records, and batteries.

E. FURNITURE AND FURNISHINGS

Rigid and Flexible Types: including household and office furniture, bedding, carpets, rugs, backing, curtains, blinds, awnings, lamps, picture frames, wall coverings.

F. CONSUMER AND INSTITUTIONAL PRODUCTS

Disposable Food Serviceware, including disposable cups
Dinner and Kitchenware: including picnicware
Toys and Sporting Goods
Health Care and Medical Products: including laboratory supplies
Hobby and Graphic Arts Supplies: including photographic equipment and supplies
All Other: including footwear, luggage, buttons, lawn & garden tools, signs and displays, credit cards.

G. INDUSTRIAL/MACHINERY

All Types: including engine and turbine parts, farm and garden machinery, construction and related equipment, machine tools, ordnance and firearms, chemical process equipment.

H. ADHESIVES/INKS/COATINGS

Adhesives and Sealants
All Other: including printing ink, magnet wire enamels, core binders, foundry facings, paper coating and glazing, paints, varnishes, and enamels.

I. RESELLERS/COMPOUNDERS

Sales of Resins Sold to Resellers, Compounders, Converters
Unclassified Sales: including calenderers whose end-use markets cannot be ascertained by the resin supplies, or resin that cannot be classified under any of the Major Market categories listed above.

J. EXPORTS

Sales of Plastic Resin exported from the U.S.

1986 RESULTS

The 1986 data reflect major market plastics resins sales and captive use data compiled by Ernst & Whinney with consumption data being reported by individual resin. The plastics resins categories included in this study are:

THERMOSETS

Epoxy
Polyester, Unsaturated
Urea and Melamine
Phenolic
All Other Thermosets

THERMOPLASTICS

Low Density Polyethylene
High Density Polyethylene
Polypropylene
Acrylonitrile-Butadiene-Styrene (ABS) and Styrene-Acrylonitrile (SAN)
Styrene Butadiene Latexes (SBL), and Other Styrene Based Latexes
OSBL), and Other Styrene Based Polymers (OSBP)
Nylon
Polyvinyl Chloride
Thermoplastic Polyester
All Other Thermoplastics

RESIN SALES & USE BY MAJOR MARKET*

(millions of pounds, dry weight basis)

MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	1,392	1,816	2,109	1,989	1,988
Packaging	10,497	11,883	12,398	12,774	13,267
Building/Construction	7,154	8,552	9,691	10,038	10,085
Electrical/Electronic	2,275	2,554	2,757	2,659	2,609
Furniture/Furnishings	1,556	2,007	2,117	2,107	2,191
Consumer & Institutional	3,269	3,886	3,986	3,975	4,123
Industrial/Machinery	241	338	400	364	361
Adhesives, Inks & Coatings	1,584	1,810	1,993	2,142	1,638
All Other	3,232	3,616	4,080	5,122	4,555
Exports	3,909	4,150	3,796	4,170	4,206
Total	35,109	40,512	43,327	45,340	45,023

*Note: All figures exclude polyurethane

COMPARATIVE PERCENTAGE DISTRIBUTION BY MAJOR MARKET

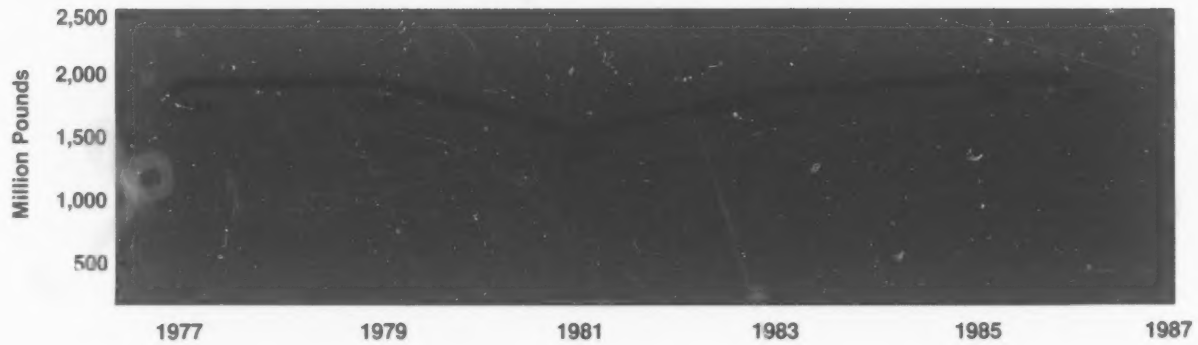
MAJOR MARKET	1982	1983	1984	1985	1986
Transportation	4.0%	4.7%	4.9%	4.4%	4.4%
Packaging	29.9	29.2	28.6	28.2	29.5
Building/Construction	20.4	21.1	22.4	22.1	22.4
Electrical/Electronic	6.5	6.2	6.4	5.9	5.8
Furniture/Furnishings	4.4	5.0	4.9	4.7	4.9
Consumer & Institutional	9.3	9.4	9.2	8.8	9.2
Industrial/Machinery	0.7	0.8	0.8	0.8	0.8
Adhesives, Inks & Coatings	4.5	4.4	4.6	4.7	3.6
All Other	9.2	9.0	9.4	11.2	10.1
Exports	11.1	10.2	8.8	9.2	9.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%

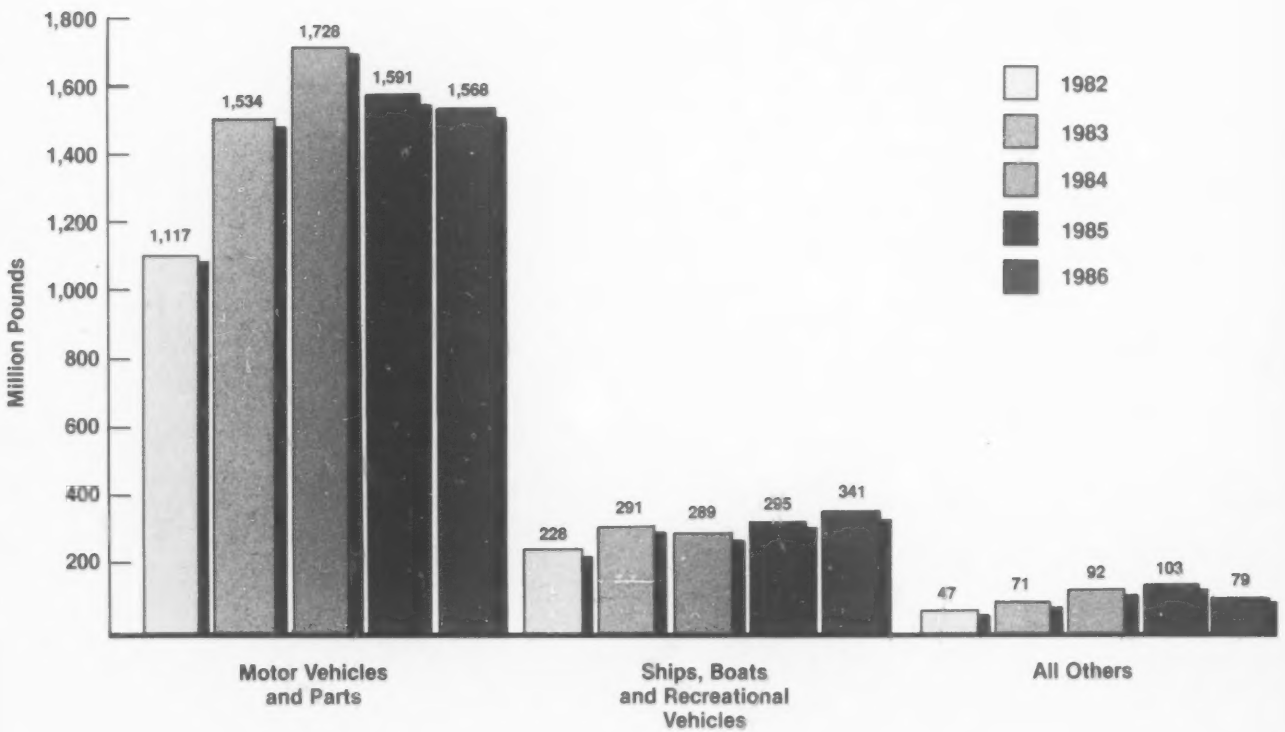
PERCENTAGE CHANGE IN SALES AND USE BY MAJOR MARKET

MAJOR MARKET	% CHANGE 1986/1985	% CHANGE 1985/1984
Transportation	-0.1%	−5.7%
Packaging	+3.9	3.0
Building/Construction	+0.5	3.6
Electrical/Electronic	-1.9	−3.6
Furniture/Furnishings	+4.0	−0.5
Consumer/Institutional	+3.7	−0.3
Industrial/Machinery	-0.8	−9.0
• Adhesives/Inks/Coatings	-23.5	7.5
All Other	-11.1	25.5
Exports	+0.9	9.9
• Total	-0.7%	4.7%

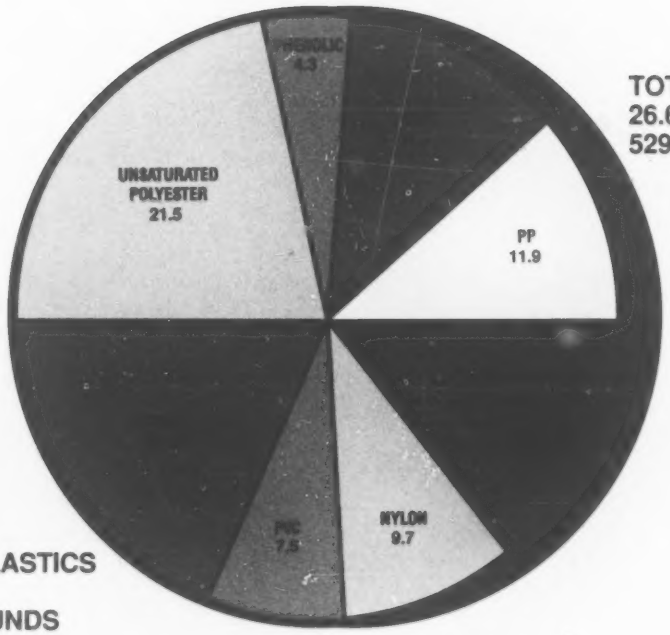
• % change approximate, due to reporting change in 1986

TRANSPORTATION





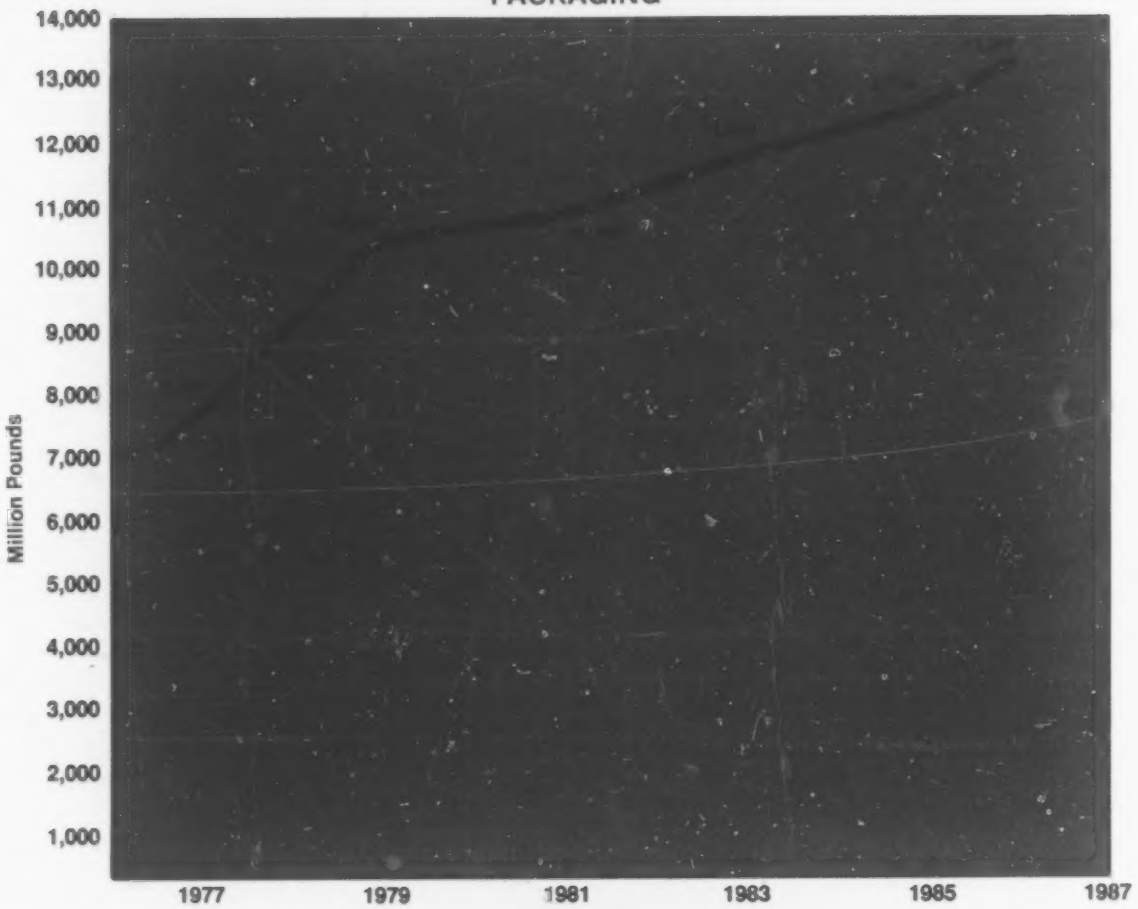
TRANSPORTATION (cont'd)

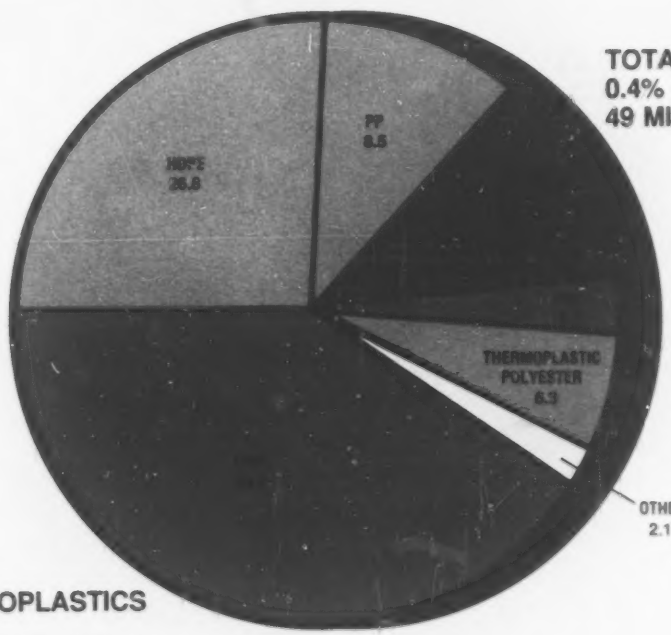


TOTAL THERMOSETS
26.6%
529 MILLION POUNDS

TOTAL THERMOPLASTICS
73.4%
1,459 MILLION POUNDS

PACKAGING

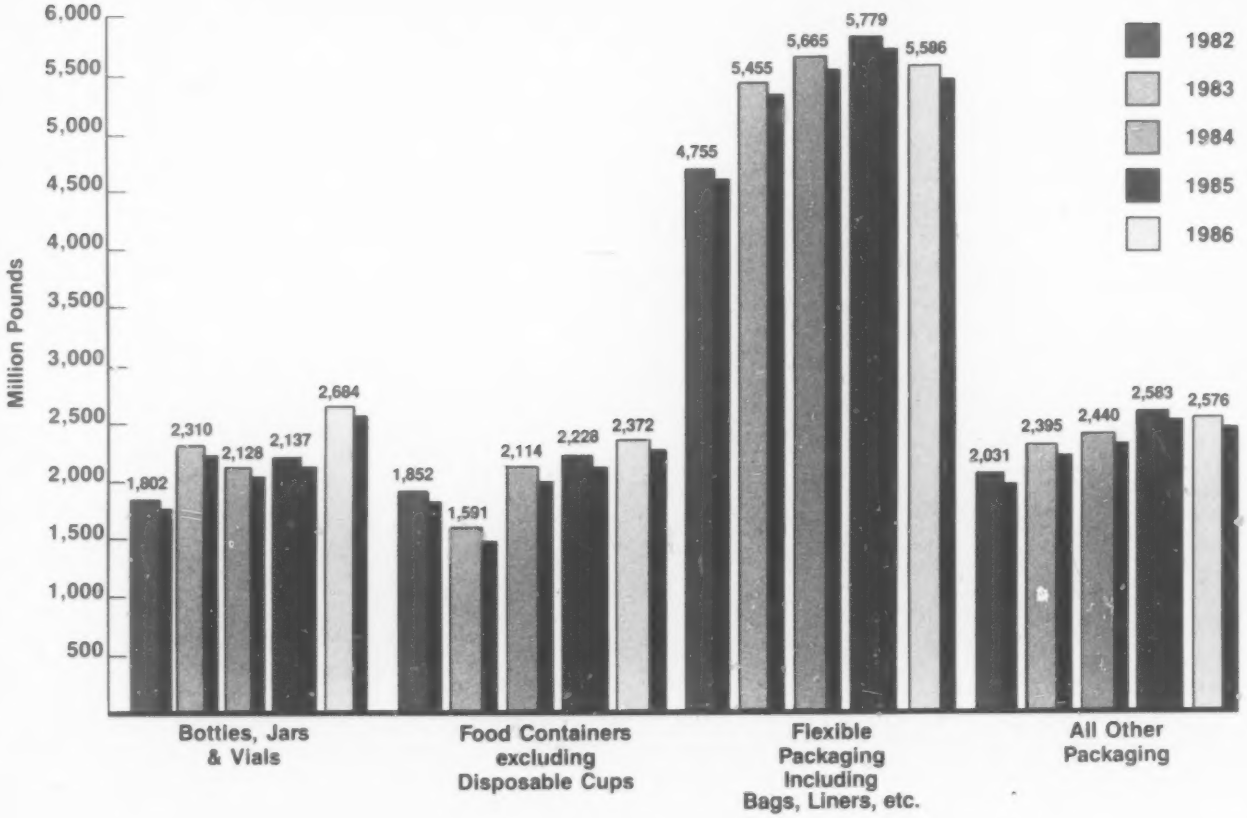




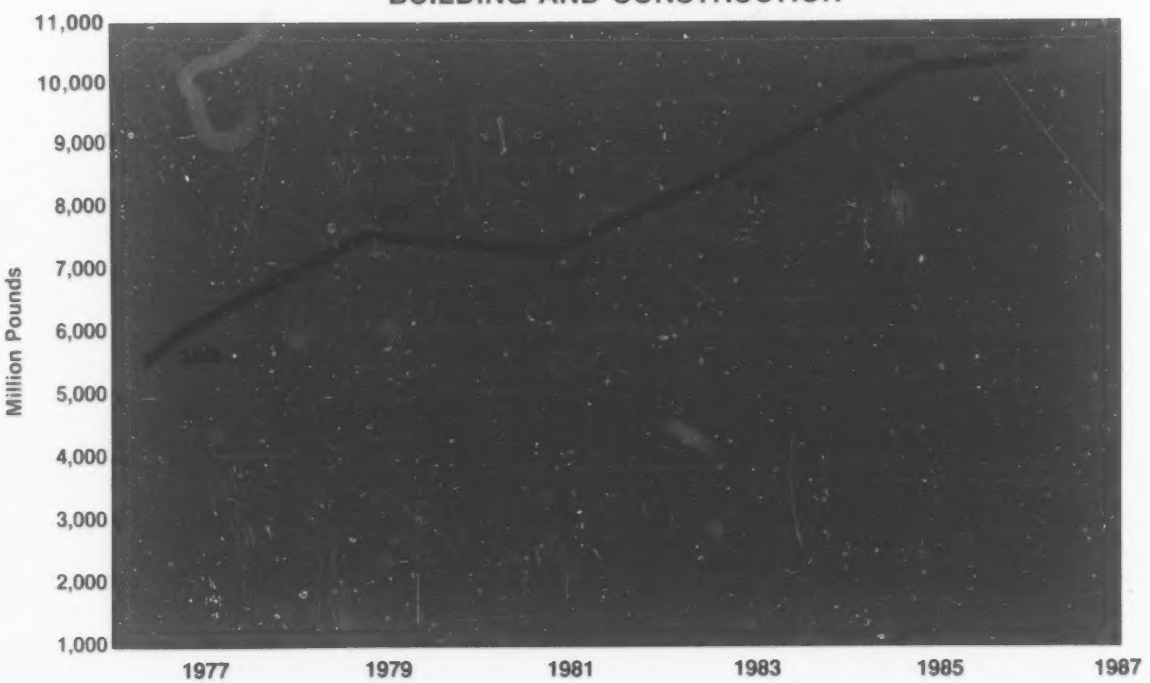
TOTAL THERMOSETS
0.4%
49 MILLION POUNDS

TOTAL THERMOPLASTICS
99.6%
13,218 MILLION POUNDS

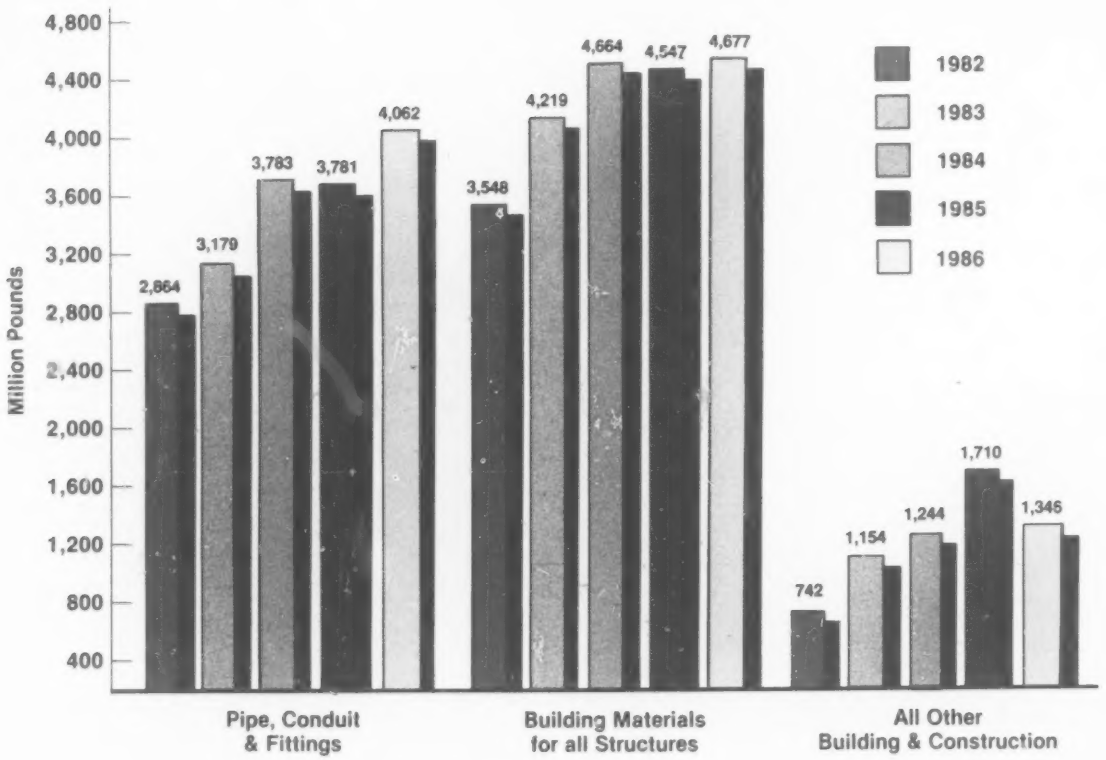
PACKAGING — THERMOPLASTIC DISTRIBUTION

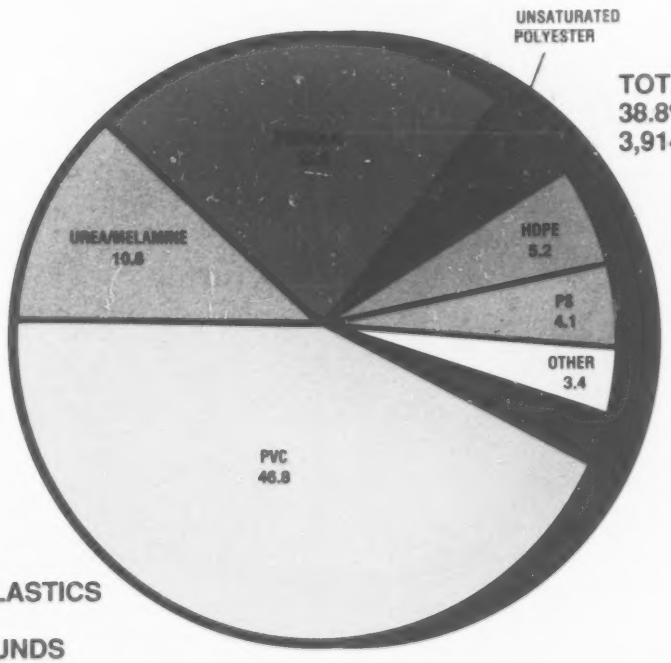


BUILDING AND CONSTRUCTION



BUILDING AND CONSTRUCTION (cont'd.)

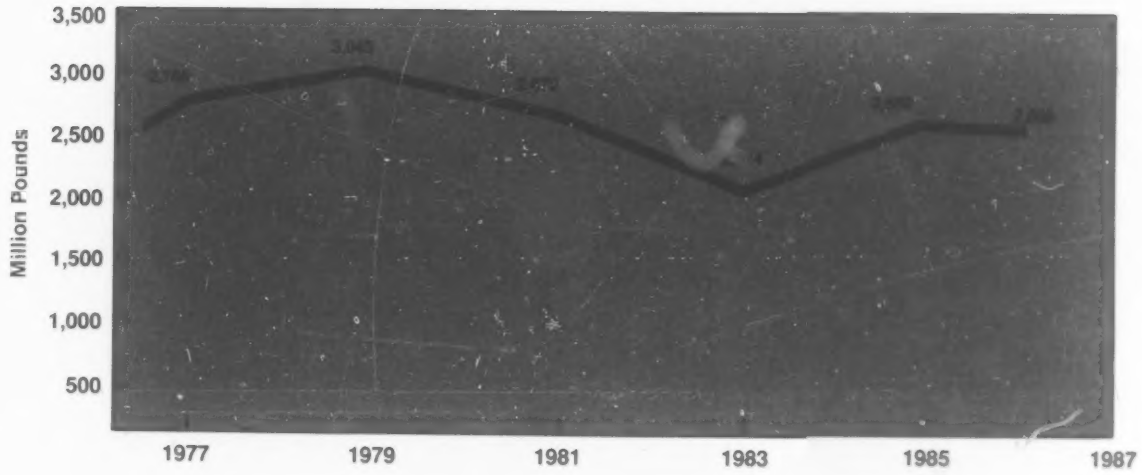


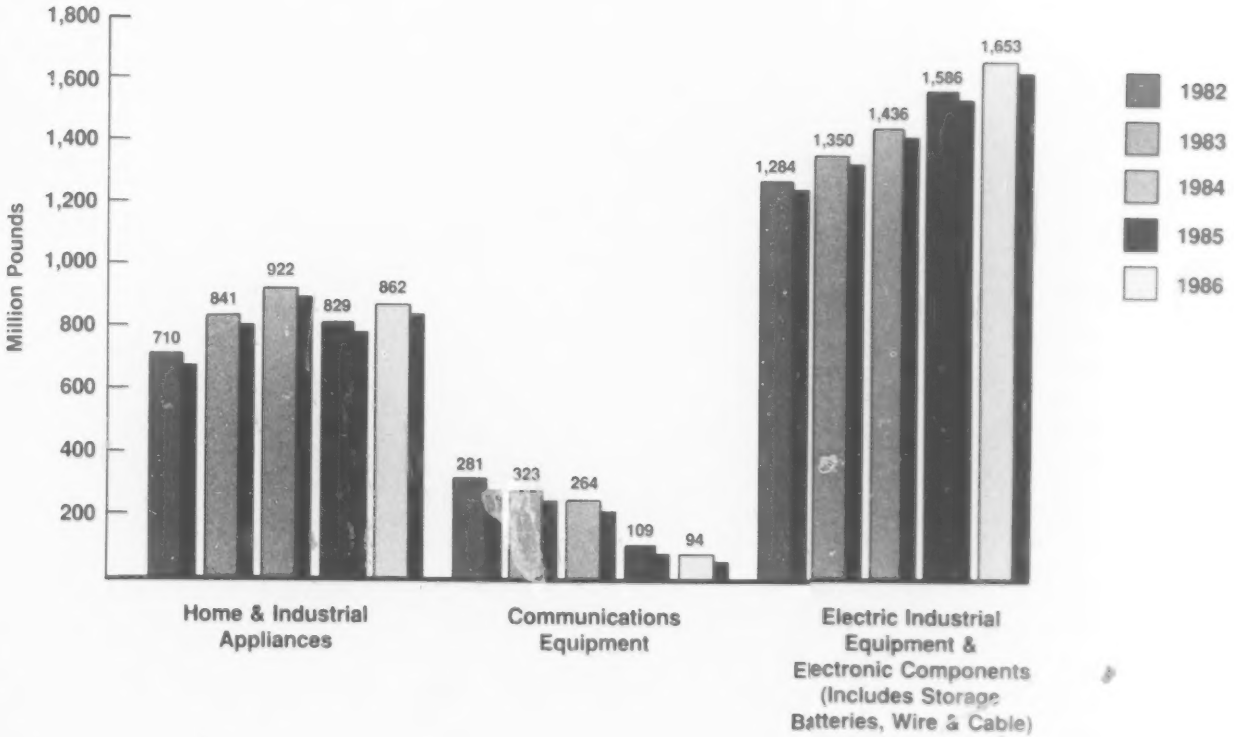


TOTAL THERMOSETS
38.8%
3,914 MILLION POUNDS

TOTAL THERMOPLASTICS
61.2%
6,171 MILLION POUNDS

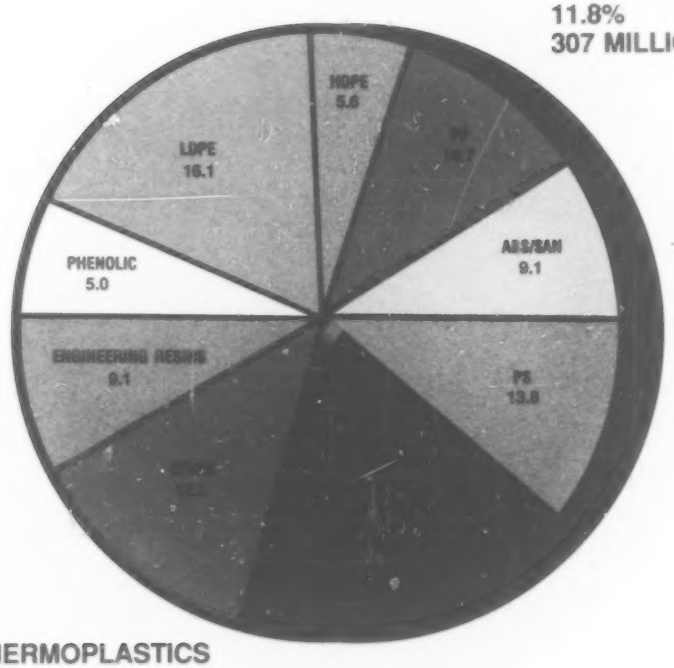
ELECTRICAL AND ELECTRONIC





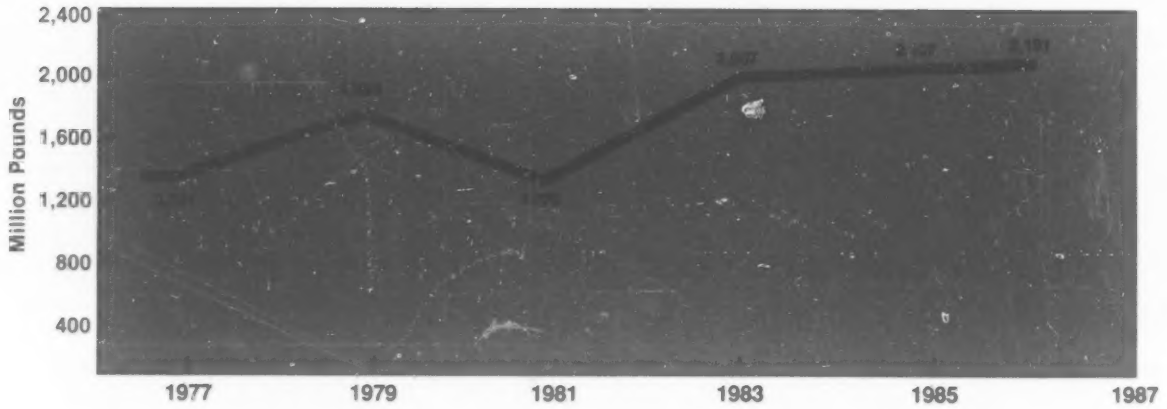
ELECTRICAL AND ELECTRONIC (cont'd.)

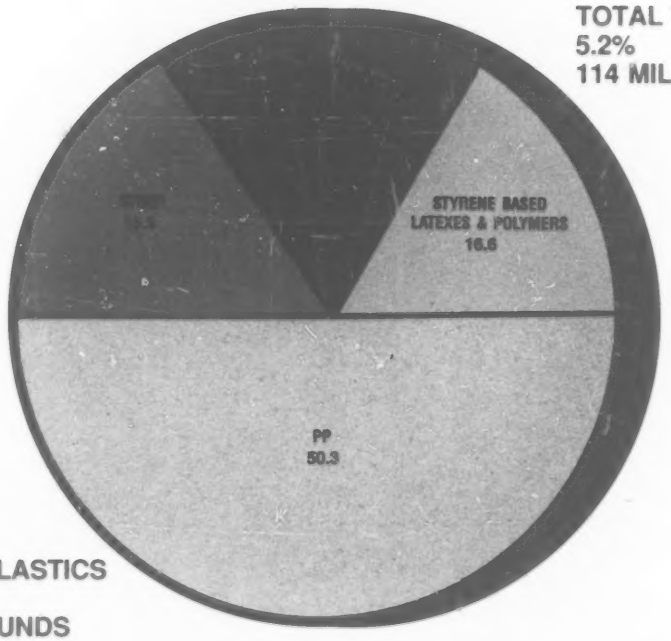
TOTAL THERMOSETS
11.8%
307 MILLION POUNDS



TOTAL THERMOPLASTICS
88.2%
2,302 MILLION POUNDS

FURNITURE AND FURNISHINGS

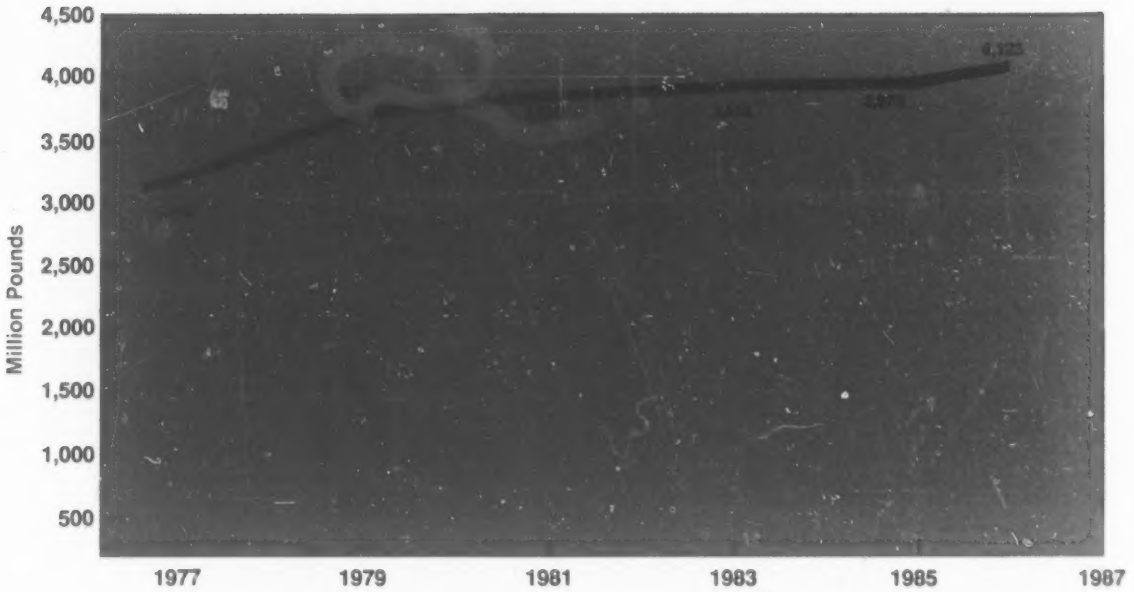


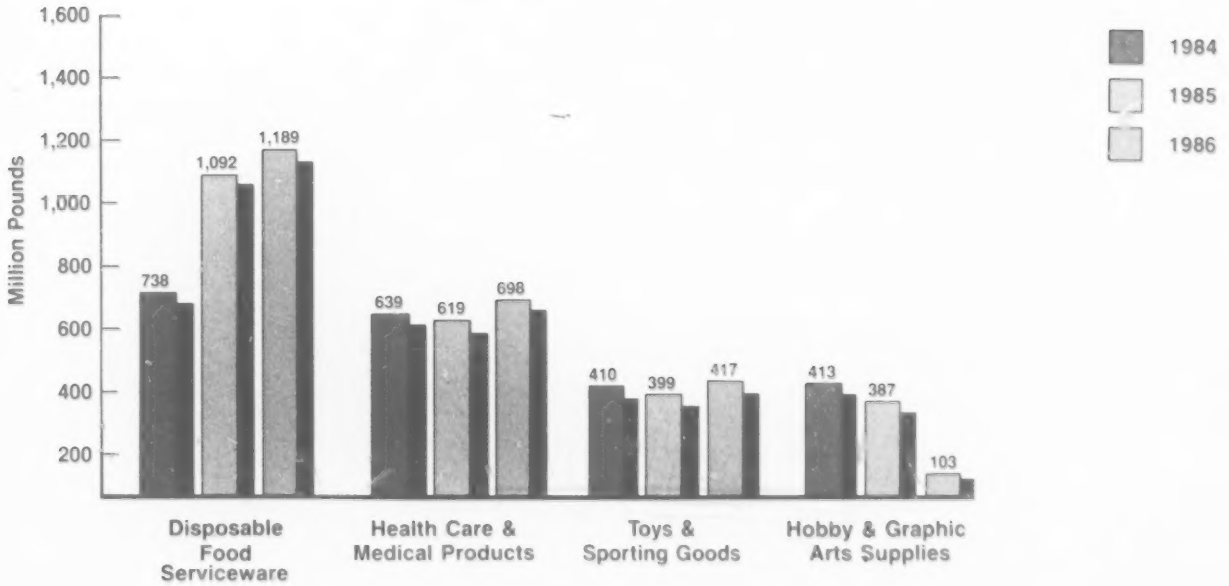


TOTAL THERMOSETS
5.2%
114 MILLION POUNDS

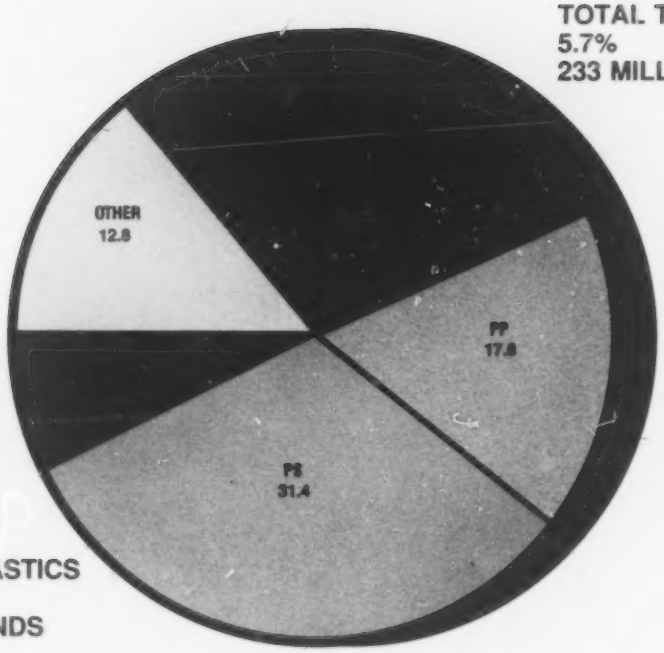
TOTAL THERMOPLASTICS
94.8%
2,077 MILLION POUNDS

CONSUMER AND INSTITUTIONAL





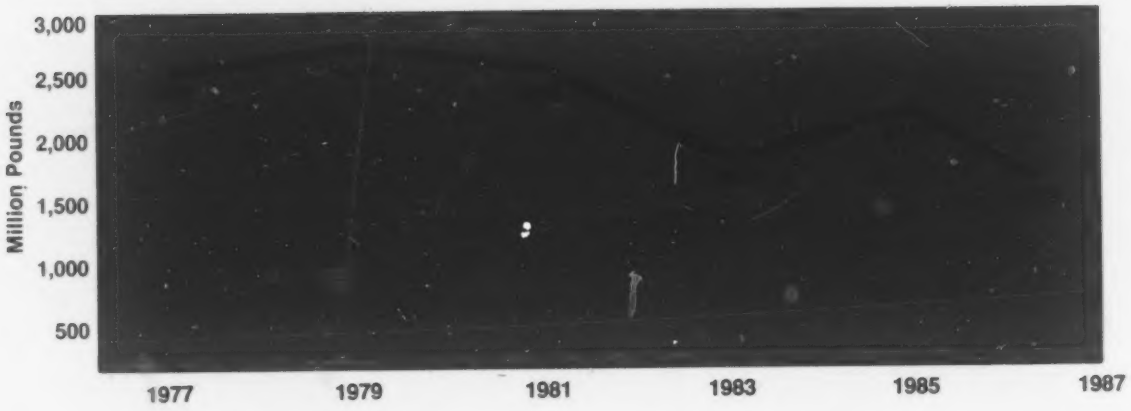
CONSUMER AND INSTITUTIONAL (cont'd.)

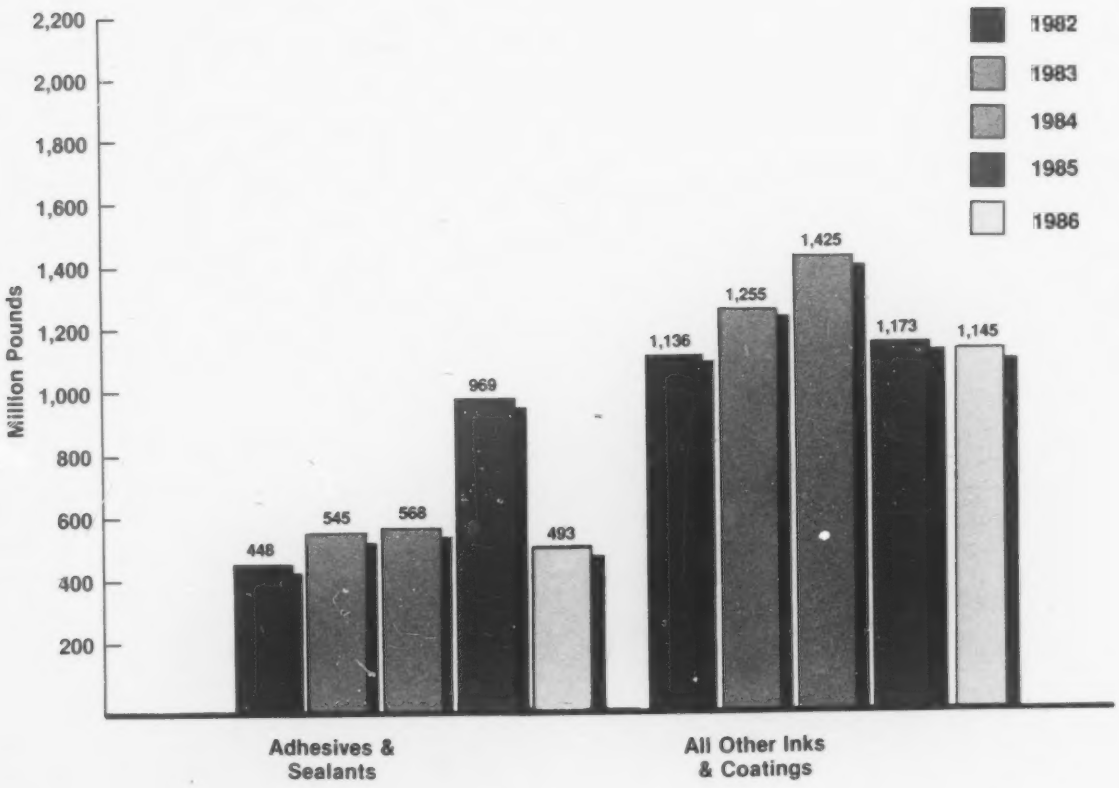


TOTAL THERMOSETS
5.7%
233 MILLION POUNDS

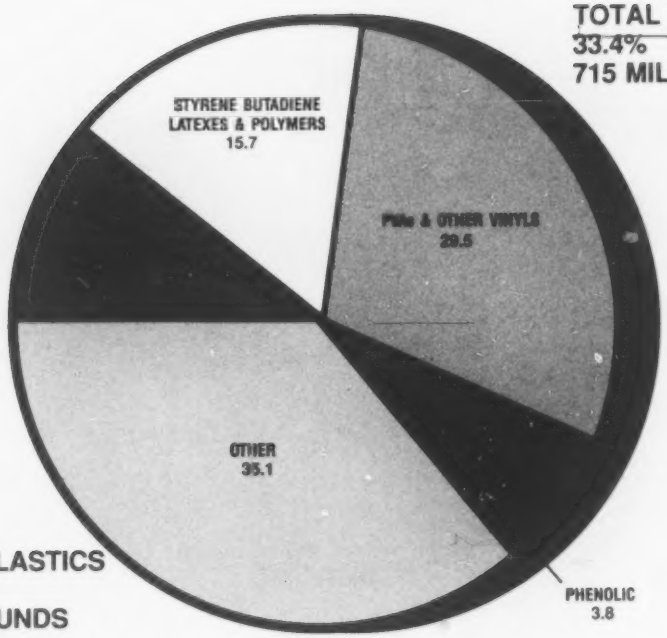
TOTAL THERMOPLASTICS
94.3%
3,890 MILLION POUNDS

ADHESIVES/INKS/COATINGS





Note: 1986 data does not include industry estimates



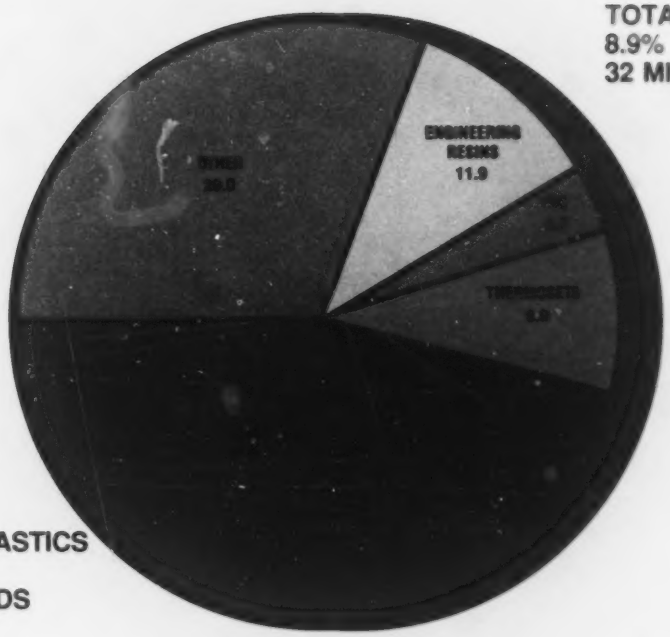
TOTAL THERMOSETS
33.4%
715 MILLION POUNDS

TOTAL THERMOPLASTICS
66.6%
1,427 MILLION POUNDS

Note: Represents 1985 Data

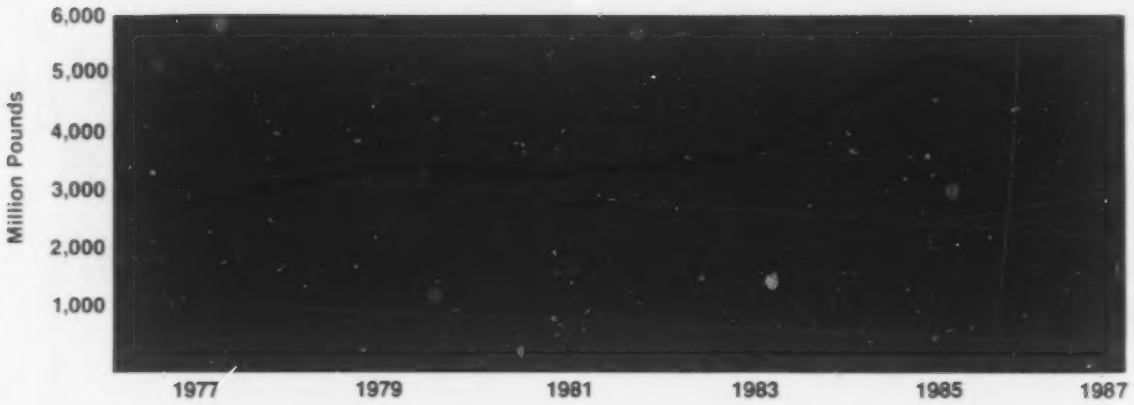
INDUSTRIAL/MACHINERY

TOTAL THERMOSETS
8.9%
32 MILLION POUNDS

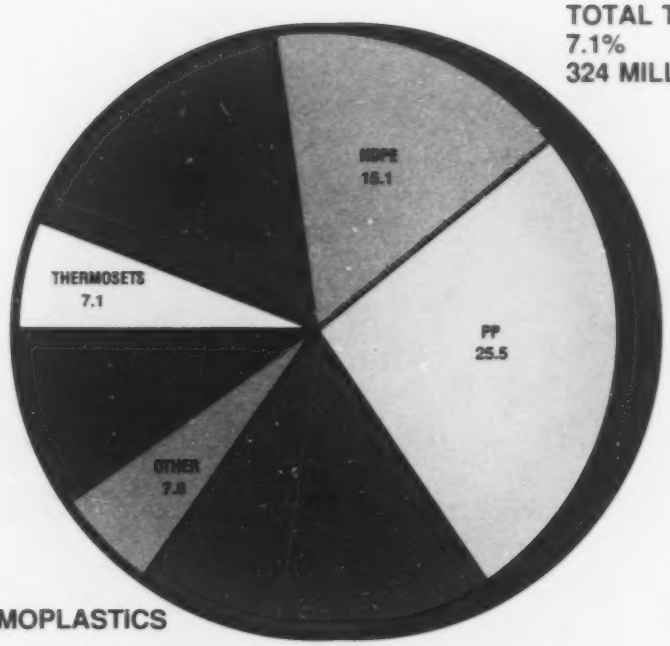


TOTAL THERMOPLASTICS
91.1%
329 MILLION POUNDS

ALL OTHER

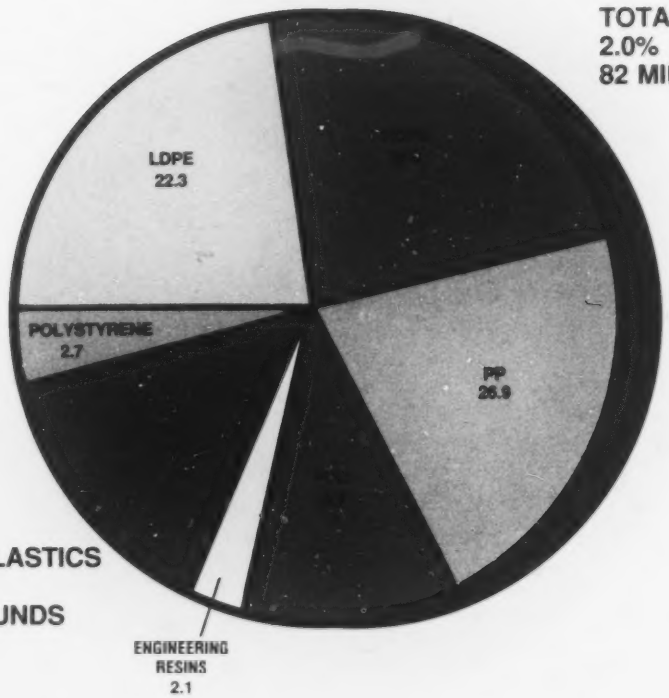


TOTAL THERMOSETS
7.1%
324 MILLION POUNDS



TOTAL THERMOPLASTICS
92.9%
4,231 MILLION POUNDS

EXPORTS



TOTAL THERMOSETS
2.0%
82 MILLION POUNDS

TOTAL THERMOPLASTICS
98.0%
4,124 MILLION POUNDS

APPENDIX A

Table of 1986 distribution of plastics resins sales and use by Major Market, including market segments.

THE SOCIETY OF THE PLASTIC INDUSTRY, INC.

1986 DISTRIBUTION OF PLASTIC RESINS SALES & USE *(CAPTIVE)* BY MAJOR MARKET

(In millions of pounds, dry weight basis) (1)

MAJOR MARKET	TOTAL THERMOSETS		TOTAL THERMOPLASTICS		GRAND TOTAL	
	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL
TRANSPORTATION, TOTAL	529	9.0	1,459	3.7	1,988	4.4
Motor Vehicles and Parts	210	3.6	1,358	3.5	1,568	3.5
Ships, Boats and Recreational Vehicles	295	5.0	46	0.1	341	0.8
All Other Transportation Equipment	24	0.4	55	0.1	79	0.2
PACKAGING, TOTAL	49	0.8	13,218	33.8	13,267	29.5
Bottles, Jars, Vials			2,684	6.9		
Food Containers (Excluding Disposable Cups)			2,372	6.1		
Flexible Packaging - *(Bags, Liners, Etc.)*	-	-	5,586	14.3	5,586	12.4
Household and Institutional Refuse Bags & Film	-	-	2,981	7.6	2,981	6.6
All Other Flexible Packaging	-	-	2,605	6.7	2,605	5.8
All Other Packaging	38	0.6	2,576	6.6	2,614	5.8
BUILDING AND CONSTRUCTION, TOTAL	3,914	66.5	6,171	15.8	10,085	22.4
Pipe, Conduit and Fittings	74	1.3	3,988	10.2	4,062	9.0
Building Materials for All Structures	3,049	51.8	1,628	4.2	4,677	10.4
Siding, Siding Accessories, and Structural Panels for Siding	879	14.9	520	1.3	1,399	3.1
Flooring	872	14.8	341	0.9	1,213	2.7
Insulation Material	652	11.1	405	1.0	1,057	2.3
All Other Building Materials for All Structures	646	11.0	362	0.9	1,008	2.2
All Other Building and Construction	791	13.4	555	1.4	1,346	3.0
ELECTRICAL/ELECTRONIC, TOTAL	307	5.3	2,302	5.9	2,609	5.8
Home and Industrial Appliances	83	1.4	779	2.0	862	1.9
Communications Equipment	21	0.4	73	0.2	94	0.2
Electric Equipment Combined with Electronic Components	203	3.5	396	1.0	599	1.3
Storage Batteries	-	-	122	0.3	122	0.3
Wire and Cable	-	-	932	2.4	932	2.1
FURNITURE AND FURNISHINGS, TOTAL	114	1.9	2,077	5.3	2,191	4.9
Rigid Furniture	107	1.8	175	0.4	282	0.6
Flexible Furniture			135	0.3		
Carpet and Carpet Components	-	-	1,271	3.2	1,271	2.8
Other Textiles and Furnishings			496	1.3		
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	233	4.1	3,890	9.9	4,123	9.2
Disposable Food Serviceware (Includes Disposable Cups)			1,189	3.0		
Health Care and Medical Products	-	-	698	1.8	699	1.6
Toys and Sporting Goods	20	0.3	417	1.1	437	1.0
Hobby and Graphic Arts Supplies			103	0.3		
All Other Consumer and Institutional Products	82	1.4	1,483	3.8	1,565	3.5
INDUSTRIAL/MACHINERY, TOTAL	32	0.5	329	0.8	361	0.8
ADHESIVES/INKS/COATINGS, TOTAL	285	4.9	1,353	3.5	1,638	3.6
Adhesives and Sealants	70	1.2	423	1.1	493	1.1
All Other Inks and Coatings	215	3.7	930	2.4	1,145	2.5
ALL OTHER, TOTAL	324	5.6	4,231	10.8	4,555	10.1
EXPORTS, TOTAL	82	1.4	4,124	10.5	4,206	9.3
GRAND TOTAL	5,869	100.0	39,154	100.0	45,023	100.0

(1) Phenolic on gross weight basis.

Note: Page 2,3,4 tables do not add vertically or horizontally due to disclosure.

Compiled by ERNST & WHINNEY, Washington, D.C., for SPI'S COMMITTEE ON RESIN STATISTICS (CRS)

THE SOCIETY OF THE PLASTIC INDUSTRY, INC.

1986 DISTRIBUTION OF PLASTIC RESINS SALES & USE *(CAPTIVE)* BY MAJOR MARKET

(In millions of pounds, dry weight basis) (1)

MAJOR MARKET	EPOXY		POLYESTER		UREA & MELAMINE		PHENOLICS	
	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL
TRANSPORTATION, TOTAL	D	D	428	33.8	D	D	85	3.1
Motor Vehicles and Parts			124	9.8				
Ships, Boats and Recreational Vehicles			286	22.6				
All Other Transportation Equipment			18	1.4				
PACKAGING, TOTAL	D	D	-	-	33	2.3	D	D
Bottles, Jars, Vials	-	-						
Food Containers (Excluding Disposable Cups)								
Flexible Packaging - *(Bags, Liners, Etc.)*	-	-			-	-		
Household and Institutional Refuse Bags & Film	-	-						
All Other Flexible Packaging	-	-						
All Other Packaging								
BUILDING AND CONSTRUCTION, TOTAL	38	10.1	505	39.9	1,093	75.0	2,278	82.2
Pipe, Conduit and Fittings			54	4.3	-			
Building Materials for All Structures	16	4.3	170	13.4				
Siding, Siding Accessories, and Structural Panels for Siding			70	5.5			808	29.2
Flooring	10	2.7					387	14.0
Insulation Material	-	-					639	23.1
All Other Building Materials for All Structures			99	7.8				
All Other Building and Construction			281	22.2				
ELECTRICAL/ELECTRONIC, TOTAL	80	21.3	D	D	D	D	130	4.7
Home and Industrial Appliances							67	2.4
Communications Equipment								
Electric Equipment Combined with Electronic Components			34	2.7				
Storage Batteries	-	-	-	-			-	-
Wire and Cable	-	-	-	-			-	-
FURNITURE AND FURNISHINGS, TOTAL	D	D	11	0.9	37	2.5	D	D
Rigid Furniture			5	0.4				
Flexible Furniture								
Carpet and Carpet Components			-	-	-	-		
Other Textiles and Furnishings								
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	D	D	70	5.5	D	D	D	D
Disposable Food Serviceware (Includes Disposable Cups)			-	-				
Health Care and Medical Products			-	-				
Toys and Sporting Goods								
Hobby and Graphic Arts Supplies								
All Other Consumer and Institutional Products			46	3.6				
INDUSTRIAL/MACHINERY, TOTAL	D	D	24	1.9	-	-	D	D
ADHESIVES/INKS/COATINGS, TOTAL	140	37.2	D	D	D	D	68	2.5
Adhesives and Sealants	20	5.3						
All Other Inks and Coatings	120	31.9						
ALL OTHER, TOTAL	23	6.1	D	D	#74	5.1	96	3.5
EXPORTS, TOTAL	57	15.2	9	.7	#D	D	16	0.6
GRAND TOTAL	376	100.0	1,265	100.0	1,457	100.0	2,771	100.0

(1) Phenolic on a gross weight basis

Urea & Melamine Exports included in All Other Sales

Compiled by ERNST & WHINNEY, Washington, D.C., for SPI'S COMMITTEE ON RESIN STATISTICS (CRS)

THE SOCIETY OF THE PLASTIC INDUSTRY, INC.

1986 DISTRIBUTION OF PLASTIC RESINS SALES & USE *(CAPTIVE)* BY MAJOR MARKET

(In millions of pounds, dry weight basis)

MAJOR MARKET	LOW DENSITY PE		HIGH DENSITY PE		POLYPROPYLENE		ABS & SAN		POLYSTYRENE		STYRENE LATEX & OSBP	
	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL
TRANSPORTATION, TOTAL	D	D	232	3.3	237	4.1	285	24.4	D	D	D	D
Motor Vehicles and Parts			220	3.1			274	23.5				
Ships, Boats and Recreational Vehicles	-						11	.9				
All Other Transportation Equipment							-	-				
PACKAGING, TOTAL	5,605	63.7	3,560	50.7	1,128	19.3	5	0.4	1,360	30.5	D	D
Bottles, Jars, Vials	54	0.6	1,354	19.3	90	1.5						
Food Containers (Excluding Disposable Cups)	492	5.6	787	11.2	224	3.8			794	17.8		
Flexible Packaging - *(Bags, Liners, Etc.)*	4,420	50.2	437	6.2	379	6.5	-	-				
Household and Institutional Refuse Bags & Film	2,703	30.7	84	1.2	99	1.7						
All Other Flexible Packaging	1,717	19.5	353	5.0	280	4.8						
All Other Packaging	639	7.3	982	14.0	435	7.5						
BUILDING AND CONSTRUCTION, TOTAL	213	2.4	522	7.4	D	D	133	11.4	418	9.4	D	D
Pipe, Conduit and Fittings	-	-	494	7.0					353	7.9		
Building Materials for All Structures	68	0.8					-	-	-	-		
Siding, Siding Accessories, and Structural Panels for Siding	-	-					-	-	337	7.4		
Flooring							-	-	16	0.4		
Insulation Material												
All Other Building Materials for All Structures												
All Other Building and Construction												
ELECTRICAL/ELECTRONIC, TOTAL	421	4.8	147	2.1	277	4.8	261	22.3	360	8.1	D	D
Home and Industrial Appliances	-	-			130	2.2	214	18.3	281	6.3		
Communications Equipment			-	-								
Electric Equipment Combined with Electronic Components	-	-	-	-	111	1.9						
Storage Batteries	356	4.0	139	2.0								
Wire and Cable												
FURNITURE AND FURNISHINGS, TOTAL	71	0.8	D	D	1,103	18.9	D	D	47	1.1	362	31.6
Rigid Furniture	-	-							22	.5	-	-
Flexible Furniture	-	-			801	13.8					-	-
Carpet and Carpet Components									-	-	326	28.4
Other Textiles and Furnishings											36	3.2
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	507	5.8	783	11.1	732	12.6	D	D	1,296	29.1	D	D
Disposable Food Serviceware (Includes Disposable Cups)	205	2.3			69	1.2			816	18.3		
Health Care and Medical Products	40	.5	72	1.0	396	6.8			67	1.5		
Toys and Sporting Goods					44	.8			172	3.9		
Hobby and Graphic Arts Supplies	223	2.5	590	8.4	13	.2			41	.9		
All Other Consumer and Institutional Products					210	3.6			200	4.5		
INDUSTRIAL/MACHINERY, TOTAL	D	D	132	1.9	D	D	D	D	D	D	D	D
ADHESIVES/INKS/COATINGS, TOTAL	231	2.6	D	D	D	D	D	D	D	D	191	14.1
Adhesives and Sealants									-	-	49	4.3
All Other Inks and Coatings											342	29.8
ALL OTHER, TOTAL	760	8.6	689	9.8	1,162	20.0	147	12.6	814	18.2	D	D
EXPORTS, TOTAL	939	10.7	924	13.1	1,130	19.4	D	D	114	2.6	73	6.4
GRAND TOTAL	8,799	100.0	7,028	100.0	5,824	100.0	1,168	100.0	4,463	100.0	1,147	100.0

Compiled by ERNST & WHINNEY, Washington, D.C., for SPI'S COMMITTEE ON RESIN STATISTICS (CRS)

THE SOCIETY OF THE PLASTIC INDUSTRY, INC.

1986 DISTRIBUTION OF PLASTIC RESINS SALES & USE *(CAPTIVE)* BY MAJOR MARKET

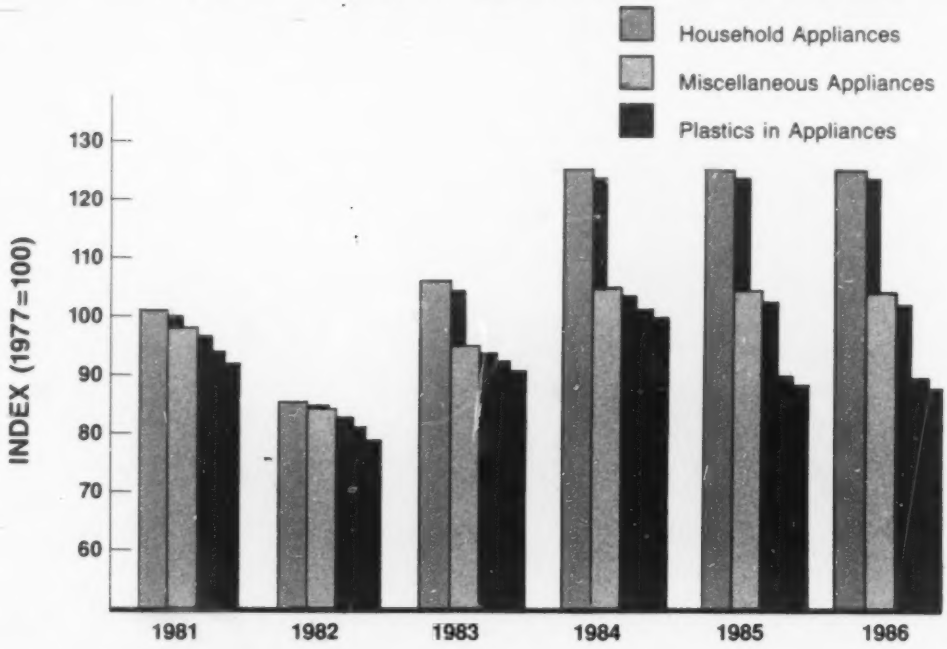
(In millions of pounds, dry weight basis)

MAJOR MARKET	NYLON		PVC		PVAc & OTHER VINYL (2)		THERMOPLASTIC POLYESTER		ENGINEERING	
	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL	QUANTITY	% OF TOTAL
TRANSPORTATION, TOTAL	192	43.3	149	2.0	D	D	D	D	D	D
Motor Vehicles and Parts										
Ships, Boats and Recreational Vehicles										
All Other Transportation Equipment										
PACKAGING, TOTAL	D	D	497	6.7	D	D	839	72.3	15	1.8
Bottles, Jars, Vials	-	-	186	2.5			784	67.6		
Food Containers (Excluding Disposable Cups)	-	-								
Flexible Packaging - *(Bags, Liners, Etc.)*			191	2.6						
Household and Institutional Refuse Bags & Film			58	0.8					-	-
All Other Flexible Packaging			133	1.8					-	-
All Other Packaging									-	-
BUILDING AND CONSTRUCTION, TOTAL	D	D	4,711	63.6	21	2.4	D	D	84	10.0
Pipe, Conduit and Fittings					-	-				
Building Materials for All Structures			1,087	14.7						
Siding, Siding Accessories, and Structural Panels for Siding			514	6.9	-	-			-	-
Flooring			316	4.3	-	-			-	-
Insulation Material			2	0.1	-	-				
All Other Building Materials for All Structures			255	3.4						
All Other Building and Construction										
ELECTRICAL/ELECTRONIC, TOTAL	71	16.0	478	6.4	D	D	48	4.1	236	28.1
Home and Industrial Appliances			15	0.2			12	1.0	97	11.5
Communications Equipment										
Electric Equipment Combined with Electronic Components	38	8.6								
Storage Batteries	-	-					-	-	-	-
Wire and Cable	23	5.2	394	5.3						
FURNITURE AND FURNISHINGS, TOTAL	6	1.4	380	5.1	57	6.6	3	0.3	D	D
Rigid Furniture	4	0.9								
Flexible Furniture					-	-				
Carpet and Carpet Components	-	-					-	-		
Other Textiles and Furnishings			176	2.4	34	3.9				
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	31	7.0	277	3.7	D	D	D	D	31	3.7
Disposable Food Serviceware (Includes Disposable Cups)										
Health Care and Medical Products			72	1.0					21	2.5
Toys and Sporting Goods										
Hobby and Graphic Arts Supplies			5	0.1					-	-
All Other Consumer and Institutional Products									-	-
INDUSTRIAL/MACHINERY, TOTAL	32	7.2	17	0.2	-	-	5	0.4	43	5.1
ADHESIVES/INKS/COATINGS, TOTAL	3	0.7	83	1.1	583	67.0	D	D	-	-
Adhesives and Sealants			44	0.6	258	29.7				
All Other Inks and Coatings			39	0.5	325	37.4				
ALL OTHER, TOTAL	24	5.4	450	6.2	13	1.5	D	D	89	10.6
EXPORTS, TOTAL	39	8.8	370	5.0	54	6.2	D	D	187	22.3
GRAND TOTAL	443	100.0	7,412	100.0	870	100.0	1,160	100.0	840	100.0

Compiled by ERNST & WHINNEY, Washington, D.C., for SPI'S COMMITTEE ON RESIN STATISTICS (CRS)

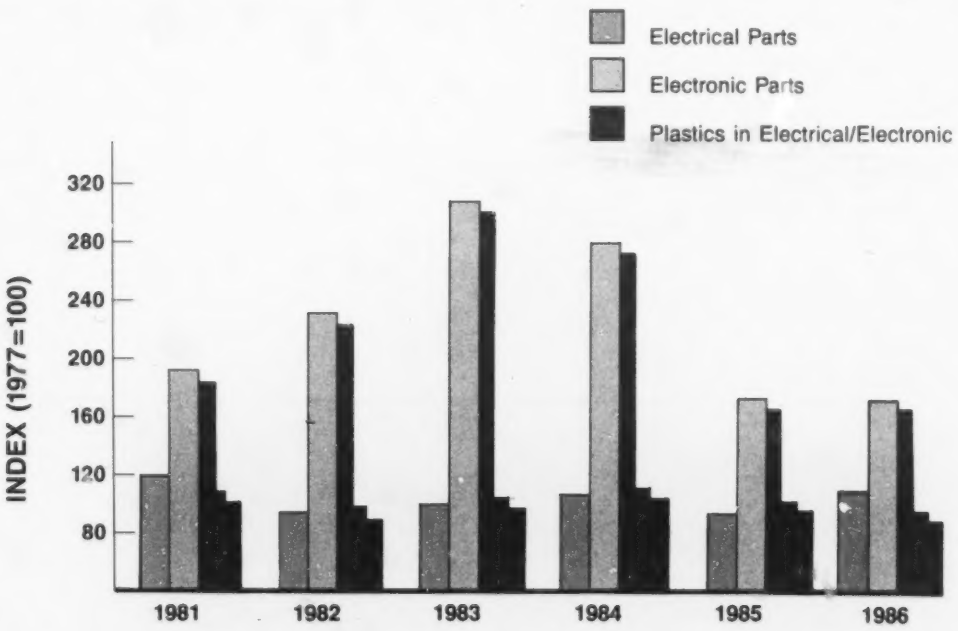
(2) The publishing of PVOH data has been temporarily suspended.

PLASTICS IN APPLIANCES vs TOTAL APPLIANCES[1]



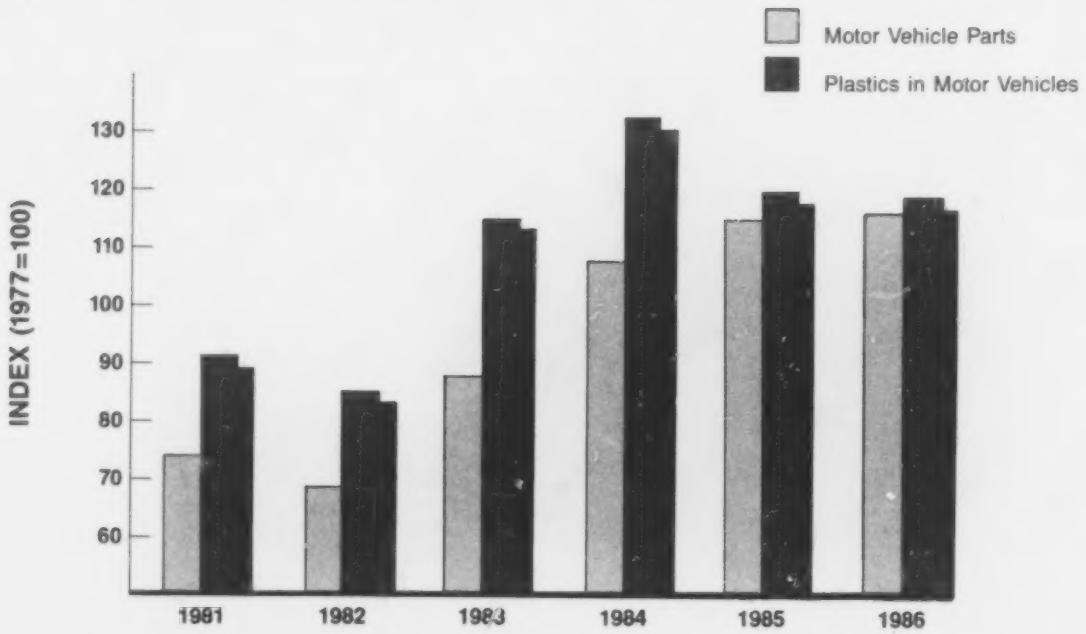
[1]Plastics Sales vs Appliance Industrial Production
Source: SPI
Modern Plastics Magazine
Survey of Current Business

PLASTICS IN ELECTRICAL/ELECTRONIC vs TOTAL ELECTRICAL/ELECTRONIC[1]



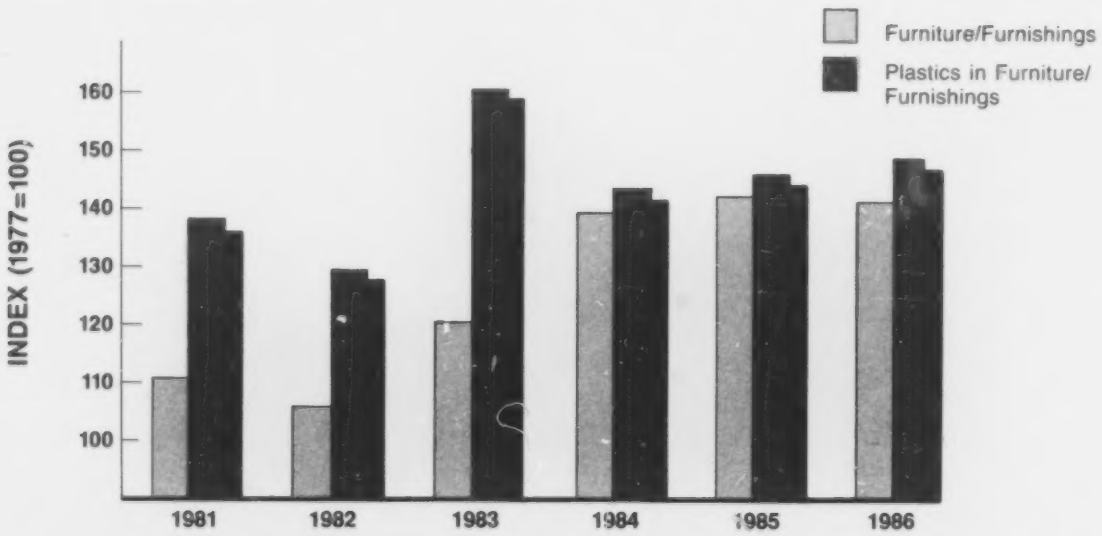
[1]Plastics Sales vs Electrical/Electronic Industrial Production
Source: SPI
Modern Plastics Magazine
Survey of Current Business

PLASTICS IN MOTOR VEHICLES vs TOTAL MOTOR VEHICLE PARTS[1]



[1]Plastics Sales vs Motor Vehicle Parts Industrial Production
Source: SPI
Modern Plastics Magazine
Survey of Current Business

PLASTICS IN FURNITURE/FURNISHINGS vs TOTAL FURNITURE/FURNISHINGS[1]



[1]Plastics Sales vs Furniture Industrial Production
Source: SPI
Modern Plastics Magazine
Survey of Current Business

PROCESSING & MACHINERY

PROCESSING METHODS

INJECTION MOLDING

Injection molding is the principal method of forming thermoplastic materials. Modifications of the injection process are sometimes used for thermosetting plastics.

In injection molding, plastic material is put into a hopper which feeds into a heating chamber. A plunger pushes the plastic through this long heating chamber where the material is softened to a fluid state. At the end of this chamber there is a nozzle which abuts firmly against an opening into a cool, closed mold. The fluid plastic is forced at high pressure through this nozzle into the cold mold. As soon as the plastic cools to a solid state, the mold opens and the finished plastic is ejected from the press.

THe problem with injection molding of thermosetting materials is that, under heat, these plastics will first soften, then harden to an infusible state. Thus it is essential that no softened thermosetting material in the heating chamber be allowed to remain there long enough to set.

Jet molding, offset molding and molding using a screw-type machine overcome this problem by liquefying the thermosetting plastic material just as it goes through the injection nozzle into the mold, but not before.

BLOW MOLDING

Blow molding is a method of forming used with thermoplastic materials.

Basically, blow molding consists of stretching and then hardening a plastic against a mold. There are two general methods of doing this type of thermoplastic molding: the direct method and the indirect method, encompassing several variations of each.

In the direct method, a glob of molten thermoplastic material is formed into the rough shape of the desired finished product. This shape is then inserted in a female mold and air blown into the plastic, as into a balloon, to force it against the sides of the mold. The formed material is then cooled before removal from the mold.

In the indirect method, a thermoplastic sheet or special shape is first heated, then clamped between a die and cover. Air pressure forced between the plastic and the cover forces the material into contact with the die, which has the contour desired in the finished product. The plastic is cooled before removal from contact with the die.

COMPRESSION MOLDING

Compression molding is the most common method of forming thermosetting materials. It is not generally used for thermoplastics.

Compression molding is simply the squeezing of a material into a desired shape by application of heat and pressure to the material in a mold.

Plastic molding powder, mixed with such materials or fillers as woodflour, cellulose and asbestos to strengthen or give other added qualities to the finished product, is put directly into the open mold cavity. The mold is then closed, pressing down on the plaastic and causing it to flow throughout the mold. It is while the heated mold is closed that the thermosetting material undergoes a chemical change which permanently hardens it into the shape of the mold. The three compression molding factors—pressure, temperature and time mold is closed—vary with the design of the finished article and the material being molded.

EXTRUSION

Extrusion molding is the method employed to form thermoplastic materials into continuous sheeting, film, tubes, rods, profile shapes, filaments, and to coat wire, cable and cord.

In extrusion, dry plastic material is first loaded into a hopper, then fed into a long heating chamber through which it is moved by the action of a continuously revolving screw. At the end of the heating chamber the molten plastic is forced out through a small opening or die with the shape desired in the finished product. As the plastic extrusion comes from the die, it is fed onto a conveyor belt where it is cooled, most frequently by blowers or by immersion in water.

In the case of wire and cable coating, the thermoplastic is extruded around a continuing length of wire or cable which, like the plastic, passes through the extruder die. The coated wire is wound on drums after cooling.

In producing wide film or sheeting, the plastic is extruded in the form of a tube. This tube may be split as it comes from the die and then stretched and thinned to the dimensions desired in the finished film.

In a different process, the extruded tubing is inflated as it comes from the die, the degree of inflation of the tubing regulating the thickness of the final film.

THERMOFORMING

Thermoforming of plastic sheet has developed rapidly in recent years. Basically, this process consists of heating thermoplastic sheet to a formable plastic state and then applying air and/or mechanical assists to shape it to the contours of a mold.

Air pressure may range from almost zero to several hundred psi. Up to approximately 14 psi (atmospheric pressure), the pressure is obtained by evacuating the space between the sheet and the mold in order to utilize this atmospheric pressure. This range, known as *vacuum forming*, will give satisfactory reproduction of the mold configuration in the majority of forming applications.

TRANSFER MOLDING

Transfer molding is most generally used for thermosetting plastics.

This method is like compression molding in that the plastic is cured into an infusible state in a mold under heat and pressure. It differs from compression molding in that the plastic is heated to a point of plasticity before it reaches the mold and is forced into a closed mold by means of an hydraulically-operated plunger.

Transfer molding was developed to facilitate the molding of intricate products with small deep holes or numerous metal inserts. The dry molding compound used in compression molding sometimes disturbs the position of the metal inserts and the pins which form the holes. The liquefied plastic material in transfer molding flows around these metal parts without causing them to shift position.

REACTION INJECTION MOLDING

Reaction injection molding (RIM) is a relatively new processing technique that has rapidly taken its place alongside more traditional methods. Unlike liquid casting, the two liquid components, polyols and isocyanates, are mixed in a chamber at relatively low temperatures (75°-140°) before injection into a closed mold. An exothermic reaction occurs and consequently RIM requires far less energy usage than any other injection molding system.

The three major types of polyurethane RIM systems are rigid structural foam, low-modulus elastomers, and high-modulus elastomers.

Reinforced RIM (R-RIM) consists in the addition of such materials as chopped or milled glass fiber to the polyurethane to enhance stiffness and to increase modulus thus expanding the range of applications.

DOLLAR SALES OF PLASTICS MACHINERY

(in millions of dollars)

MACHINE TYPE	1982	1983	1984[a]	1985	1986
Injection Molding	225.0	298.0	457.0	376.0	315.0
Structural Foam	5.0	4.5	4.5	4.5	3.9
Extrusion, single screw	140.0	85.0	137.0	84.5	121.0
Extrusion, multi screw	19.0	18.5	22.0	16.0	14.5
Blow Molding	89.0	120.0	105.0	65.0	80.0
Thermoforming	28.0	33.0	44.0	50.0	55.0
Reaction-Injection Molding	6.0	8.0	10.0	7.5	6.0
Compression	17.5	17.0	16.5	13.0	13.5
Expanded Bead	5.0	8.0	8.0	1.0	0.5
Transfer Molding	6.0	5.5	5.5	4.5	5.0
Total	540.5	597.5	809.5	622.0	614.4

[a]Revised from 1985 edition
Source: *Modern Plastics* Magazine

SHIPMENTS OF SINGLE SCREW EXTRUSION MACHINERY

(in number of units)

SCREW DIAMETER	1982	1983	1984	1985	1986
Up To But Not Including 2″	129	168	184	156	172
2″ Up To But Not Including 2½″	131	126	168	115	114
2½″ Up To But Not Including 3″	184	163	267	235	212
3″ Up To But Not Including 4″	148	165	198	216	213
4″ Up To But Not Including 5½″	127	85	181	140	134
5½″ Up To But Not Including 7½″	45	60	106	76	75
Includes 7½″ & Larger	8	5	12	16	5
Total	772	772	1,116	954	925

Note: Includes domestic shipments and exports
Source: SPI Machinery Division

SHIPMENTS OF INJECTION MOLDING MACHINERY

(in number of units)

CLAMP FORCE (Tons)	1982	1983	1984	1985	1986
Domestic Shipments					
0–199	683	848	1,239	a	608
200–299	d	363	485	1,316	280
300–399	253	b	484	411	f
400–499	276	b	f	b	f
500–599	89	543	f	280	f
600–749	83	f	f	f	f
750–1199	e	f	f	f	f
1200–1999	e	f	f	f	f
2000 and Over		106	402	246	739
Total	1,384	1,860	2,610	2,253	1,627
Export Shipments					
0–199	25	34	39	a	40
200–299	d	12	22	44	15
300–399	13	b	22	12	f
400–499	25	b	f	b	f
500–599	8	14	f	9	f
600–749	14	f	f	f	f
750–1199	e	f	f	f	f
1200–1999	e	f	f	f	f
2000 and Over		2	12	14	27
Total	85	62	95	79	82
Total Shipments					
0–199	708	882	1,278	a	648
200–299	d	375	507	1,360	295
300–399	266	b	506	423	f
400–499	301	b	f	b	f
500–599	97	557	f	289	f
600–749	97	f	f	f	f
750–1199	e	f	f	f	f
1200–1999	e	f	f	f	f
2000 and Over		108	414	260	766
Grand Total	1,469	1,922	2,705	2,332	1,709

[a] Combined with 200–299 [b] Combined with 500–599 [c] Combined with 100–199

[d] Combined with 400–499 [e] Combined with 600–749 [f] Combined with 2000 and over

Source: SPI Machinery Division

GLOSSARY OF SELECTED PLASTICS PROPERTIES

ABLATION — The degradation and decomposition of a material caused by high heat friction.

ABRASION RESISTANCE — Ability to resist surface wear.

AGING — The effect, on materials, of exposure to an environment for an interval of time.

ARC RESISTANCE — The total time in seconds that an intermittent arc may play across a plastic surface without rendering the surface conductive.

BLEEDING — The diffusion of color out of a plastic part into the surrounding surface of part.

BLOCKING — The adhesion between touching layers of plastic, such as that which may develop under pressure during storage or use.

BLOOM — A visible exudation or efflorescence on the surface of a plastic; bloom can be caused by lubricant, plasticizer, etc.

BRITTLE POINT — The highest temperature at which an elastomer fractures in a prescribed impact test procedure.

BRITTLE TEMPERATURE — The lowest temperature at which a plastic material withstands given conditions without failure.

BUCKLING — Crimping of the fibers in a composite material, often occurring in glass-reinforced thermosets due to resin shrinkage during cure.

BULK DENSITY — The density of a molding material in loose form (granular, nodular, etc.) expressed as a ratio of weight to volume.

BULK FACTOR — The ratio of the volume of a molding compound or powdered plastic to the volume of the solid piece produced from it.

COEFFICIENT OF EXPANSION — The fractional change in dimension of a material for a unit change in temperature.

COEFFICIENT OF FRICTION — A measure of the resistance to sliding of one surface in contact with another surface.

COEFFICIENT OF LINEAR EXPANSION — A measure of the change in dimension of an object caused by a change in temperature; specifically measured by the increase in length of an object per unit degree change in temperature.

COEFFICIENT OF THERMAL EXPANSION — The change in volume per unit volume produced by a one degree rise in temperature.

COMPRESSIVE STRENGTH — The ability of a material to resist a force that tends to crush.

CORROSION RESISTANCE — The ability of a material to withstand contact with ambient natural factors or those of a particular artificially created atmosphere.

CRACK — An actual separation of molded material, visible on opposite surfaces of the part, and extending through the thickness; a fracture.

CRAZING — Fine cracks which may extend in a network on or under the surface of a plastic material.

CREEP — The change in dimension of a plastic under load over a period of time, not including the initial instantaneous elastic deformation.

CROSS-LINKING — Applied to polymer molecules, the setting-up of chemical links between the molecular chains. When extensive, as in most thermosetting resins, cross-linking makes one infusible supermolecule of all the chains.

DEFLECTION TEMPERATURE UNDER LOAD — The temperature at which a simple beam has deflected a given amount under load (formerly called heat distortion temperature).

DEFORMATION — Any change of form or shape in a body; the linear change of dimension of a body in a given direction produced by the action of external forces.

DEGRADATION — A deleterious change in the chemical structure of a plastic.

DETERIORATION — A permanent change in the physical properties of a plastic evidenced by impairment of these properties.

DIMENSIONAL STABILITY — Ability of a plastic part to retain the precise shape to which it was molded, cast, or otherwise fabricated.

DISCOLORATION — Any change from an initial color possessed by a plastic; a lack of uniformity in color where color should be uniform over the whole area of a plastic object.

ELASTICITY — That property of plastics materials by virtue of which they tend to recover their original size and shape after deformation.

ELASTOMERIC — The property of a material which at room temperature can be stretched under low stress to at least twice its original length and, upon immediate release of the stress, will return with force to its approximate original length.

ELECTRICAL STRENGTH [DIELECTRIC STRENGTH] — That property of an insulating material which enables it to withstand electric stress; the highest electric stress which an insulating material can withstand for a specified time without the occurrence of electrical breakdown by any path through its bulk.

ELONGATION — Deformation caused by stretching; the fractional increase in length of a material stressed in tension.

ENVIRONMENTAL STRESS CRACKING — The susceptibility of a thermoplastic resin to crack or craze when in the presence of surface active agents or other environments.

EXTENSIBILITY — The ability of a material to extend or elongate upon application of sufficient force, expressed as a percent of the original length.

EXUDATION — The formation in liquid form of a plasticizer on the surface of a plasticized resin.

FADING — Any lightening of an initial color possessed by a plastic; measured by accelerating the process by subjecting the plastic to high intensity ultraviolet rays of approximately the same wave length as those found in sunlight.

FATIGUE — The failure or decay of mechanical properties after repeated applications of stress.

FLAMMABILITY — Measure of the extent to which a material will support combustion.

FLEX LIFE — The time of heat-aging that an insulating material can withstand before failure when bent around a specific radius (used to evaluate thermal endurance).

FLEXURAL STRENGTH — The resistance of a material to being broken by bending stresses.

FLOW MARKS — Wavy surface appearance of an object molded from thermoplastic resins, caused by improper flow of the resin into the mold.

GEL POINT — The stage at which a liquid begins to exhibit pseudoelastic properties. Also known as "gel time."

GLASS TRANSITION TEMPERATURE — The center of the temperature range in which a noncrystalline solid changes from being glass-brittle to being viscous.

GLOSS — Brightness or luster of a plastic resulting from a smooth surface.

HAZE — Cloudy appearance within, or on the surface of, a plastic.

HEAT DISTORTION POINT — The temperature at which a standard test bar deflects under a stated load.

HEAT RESISTANCE — The property or ability of plastics and elastomers to resist the deteriorating effects of elevated temperatures.

HYDROLYSIS — Chemical decomposition of a substance involving the addition of water.

HYDROPHILIC — Capable of absorbing water.

HYDROPHOBIC — Capable of repelling water.

HYDROSCOPIC — Capable of adsorbing and retaining atmospheric moisture.

IMPACT STRENGTH — The ability of a material to withstand shock loading.

LACK OF FILLOUT — An area, occurring usually at the edge of a laminated plastic, where the reinforcement has not been wetted with resin.

MELT INDEX — The amount in grams, of a thermoplastic resin which can be forced through a 0.0825 inch orifice when subjected to 2160 grams force in 10 minutes.

MELTING POINT — The temperature at which a resin changes from a solid to a liquid.

MELT STRENGTH — The strength of a plastic while in the molten state.

MIGRATION — The transfer of a material from a plastic body to other contacting solids.

MOISTURE ABSORPTION — The pick-up of water vapor from air by a material. It relates only to vapor withdrawn from the air by a material and must be distinguished from water absorption, which is the gain in weight due to the take-up of water by immersion.

MOTTLE — The desired or accidental mixture of colors or shades of a color giving more or less distinct or complicated patterns or specks, spots, or streaks of color; any irregular imperfections on the surface.

NECKING — The localized reduction in cross-section which may occur in a material under tensile stress.

OPALESCENCE — The limited clarity of vision through a sheet of transparent plastic at any angle, because of diffusion within or on the surface of the plastic.

OPTICAL DISTORTION — Any apparent alteration of the geometric pattern of an object when seen through a plastic or as a reflection from a plastic surface.

OXIDATION — The chemical reaction involving the process of combining with oxygen to form an oxide; the deterioration of an adhesive film due to atmospheric exposure; the breakdown of a hot melt adhesive due to prolonged heating and oxide formation.

PIT — Small regular or irregular crater in the surface of a plastic, usually with width approximately of the same order of magnitude as its depth.

PLASTICITY — A property of plastics which allows the material to be deformed continuously and permanently without rupture upon the application of a force that exceeds the yield value of the material. (The opposite of "elasticity.").

SHEARING — Breaking caused by the action of equal and opposed forces, located in the same plane.

SPECIFIC GRAVITY — The ratio of the weight of any volume of a substance to the weight of an equal volume of another substance taken as standard at a constant or stated temperature. Solids and liquids are usually compared.

SPECIFIC HEAT — The quantity of heat required to raise the temperature of a unit mass of a substance one (1) degree under specified conditions.

STRESS-CRACK — External or internal cracks in a plastic caused by tensile stresses less than that of its short-time mechanical strength.

SWEATING — Exudation of small drops of liquid, usually a plasticizer or softener, on the surface of a plastic part.

SWELL — A dimensional increase caused by exposure to liquids and/or vapors.

TEAR RESISTANCE — The force required to tear completely across a notched specimen tested according to prescribed procedures, expressed in pounds per inch of specimen thickness.

TENSILE STRENGTH OR STRESS — The maximum tensile load per unit area of original cross section, within the gage boundaries, sustained by the specimen during a tension test.

THERMAL CONDUCTIVITY — Ability of a material to conduct heat.

THERMOELASTICITY — Rubber-like elasticity exhibited by a rigid plastic and resulting from an increase of temperature.

THERMOPLASTICITY — The ability for material to be deformed without breaking with a relatively fast flow, when (at a suitable temperature) this material is properly stressed.

TUNNELING — A condition occurring in incompletely bonded laminates, characterized by release of longitudinal portions of the substrate and deformation of these portions to form tunnel-like structures.

VISCOSITY — The property of resistance to flow exhibited within the body of a material, expressed in terms of relationship between applied shearing stress and resulting rate of strain in shear.

WEATHERING — The exposure of plastics outdoors.

OTHER SOURCES OF PLASTICS INFORMATION

Business Consulting Groups and Publishers

Business Communications Co., Inc. - 25 Van Zant St., Norwalk, CT 06855 - 203/853-4266
Chem Systems Inc. - 303 S. Broadway, Tarrytown, NY 10591 - 914/631-2828
Eldib Engineering & Research, Inc. - 613 Springfield Ave., Berkeley Heights, NJ 07922 - 201/464-2244
Frost & Sullivan, Inc. - 106 Fulton St., New York, NY 10038 - 212/233-1080
Hull & Co. - P.O. Box 4250 Greenwich, CT 06831 - 203/622-9120
Charles H. Kline & Co. - 330 Passaic Ave., Fairfield, NJ 07006 - 201/227-6262
R.M. Kossoff & Associates, Inc. - 10 Rockefeller Plaza, New York, NY 10020 - 212/246-4035
Arthur D. Little, Inc. - 25 Acorn Park, Cambridge, MA 02140 - 617/864-5770
Margolis Marketing & Research Co. - 232 Madison Ave., Suite 905, New York, NY 10016-2978 - 212/685-1278
Market Search, Inc. - 2727 Holland Sylvania Rd., Toledo, OH 43615 - 419/535-7899
Morton Research Corporation - 28 Merrick Ave., Merrick, NY 11566 - 516/378-1066
Noyes Data Corp. - Mill Road at Grand Ave., Park Ridge, NJ 07656 - 201/391-8484
Predicasts, Inc. - 11001 Cedar Ave., Cleveland, OH 44106 - 216/795-3000
Peter Sherwood Associates, Inc. - 20 Haarlem Ave., White Plains, NY 10603 - 914/761-3033
Skeist Laboratories, Inc. - 375 Route 10, Whippany, NJ 07981 - 201/515-2020
Springborn Group - 10 Springborn Ctr., Enfield, CT 06082 - 203/749-8371
SRI International - 333 Ravenswood Ave., Menlo Park, CA 94025 - 415/326-6200
The Target Group - 1000 Harston Lane, Philadelphia, PA 19118 - 215/233-4083
Technomic Consultants, Inc. - 300 South Riverside Plaza, Chicago, IL 60606 - 312/876-0004
Technomic Publishing Co. - 851 New Holland Ave., Box 3535, Lancaster, PA 17604 - 717/291-5609

Government Publications

Annual Survey of Manufacturers - Bureau of the Census
Census of Manufacturers - Bureau of the Census
Current Industrial Reports - Bureau of the Census
Foreign Trade Reports: FT 135 (imports), FT 410 (exports) - Bureau of the Census
Guide to Census Bureau Data Files and Special Tabulations - Bureau of the Census
Guide to Foreign Trade Statistics - Bureau of the Census
Producer Price Indexes - Bureau of Labor Statistics
Standard Industrial Classification Manual - Office of Management and Budget
Statistical Abstract of the U.S. - Department of Commerce
Statistical Services of the U.S. Government - Office of Management and Budget
Synthetic Organic Chemicals - International Trade Commission
U.S. Industrial Outlook - Department of Commerce

Newspapers

Chemical Marketing Reporter - 100 Church St., New York, NY 10007 - 212/732-9820
Journal of Commerce - 110 Wall St., New York, NY 10005 - 212/425-1616
Rubber & Plastics News - 1725 Merrinan Rd., Suite 300, Akron, OH 44313 - 216/836-9180

Trade Associations & Professional Organizations

American Chemical Society - 1155 16th St., NW, Washington, D.C. 20036 - 202/872-4600
Chemical Data, Inc. - 2900 N. Loop West, Suite 830 - Houston, TX 77092 - 713/683-3900
Chemical Manufacturers Assn. - 2501. M St., NW, Washington, D.C. 20037 - 202/887-1100
Chemical Marketing Research Assn. - 139 Chestnut Ave., Staten Island, NY 10305 - 718/727-0550
Chemical Specialties Manufacturers Assn. - 1001 Connecticut Ave., NW, Washington, D.C. 20036 - 202/872-8110
Composite Can & Tube Institute - 1818 N St., NW, Suite T-10, Washington, D.C. 20036 - 202/223-4840
Drug, Chemical & Allied Trades Assn. - 42-40 Bell Blvd., Suite 604, Bayside, NY 11361 - 718/229-8891
Dry Color Manufacturers Assn. - Suite 202, 206 N. Washington St., P.O. Box 20839, Alexandria, VA 22314 - 703/684-4044
Flexible Packaging Assn. - Suite 500, 1090 Vermont Ave., NW, Washington, D.C. 20005 - 202/842-3880
INDA - 1700 Broadway, New York, NY 10019 - 212/582-8401
International Institute of Synthetic Rubber Producers - 2077 S. Gessner Rd., Suite 133, Houston, TX 77063 - 713/783-7511
International Isocyanate Institute - 119 Cherry Hill Rd., Parsipanny, NJ 07054 - 201/263-7517
National Paint & Coatings Assn. - 1500 Rhode Island Ave. NW, Washington, D.C. 20005 - 202/462-6272
Polyurethane Manufacturers Assn. - 800 Roosevelt Rd., Bldg. C, Suite 20, Glen Ellyn, IL 60137 - 312/858-2670
Rubber Manufacturers Assn. - 1400 K St., NW, Washington, D.C. 20005 - 202/682-1338
Society of Plastics Engineers - 14 Fairfield Drive, Brookfield Center, CT 06805 - 203/775-0471
Society of the Plastics Industry-Canada - 1262 Don Mills Rd., Suite 104, Don Mills, Ontario M3B2W7 - 416/449-3444
Synthetic Organic Chemical Manufacturers Assn. - 1330 Connecticut Ave., NW, Suite 300, Washington, D.C. - 202/659-0060

Trade Publications

Canadian Plastics - 1450 Don Mills Road, Ontario M3B2X7 - 416/445-6641
Chemical Engineering - 1221 Ave. of the Americas, New York, NY 10020 - 212/512-3198
Chemical & Engineering News - 1155 16th St., NW, Washington, D.C. 20036 - 202/872-4600
Chemical Week - 1221 Ave. of the Americas, New York, NY 10020 - 212/512-2922
Materials Engineering - 1100 Superior Ave., Cleveland, OH 44114 - 216/696-7000
Modern Plastics 0 1221 Ave. of the Americas, New York, NY 10020 - 212/512-6243
Packaging Digest - 122 East 42nd St., New York, NY 10168 - 212/867-9191
Plastics Compounding - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Connection - P.O. Box 814, Amherst, MA 01004 - 413/549-5020
Plastics Design Forum - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Design & Processing - 17730 Peterson Rd., Libertyville, IL 60048 - 312/362-8711
Plastics Engineering - 14 Fairfield Drive, Brookfield Center, CT 06805 - 203/775-0471
Plastics Industry News - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Machinery & Equipment - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Technology - 633 Third Ave., New York, NY 10017 - 212/986-4800
Plastics World - 275 Washington St., Newton, MA 02158 - 617/964-3030

MONTHLY STATISTICAL REPORT
on
THERMOSETTING & THERMOPLASTIC RESINS

This publication is the only source of monthly detailed data on production and sales & use (captive) available. A sample of the report follows on the next page. The following materials are included:

Epoxy	Polypropylene	Other Styrene-based Polymers
Polyester	ABS	Nylon
Urea	SAN	PVC
Melamine	Polystyrene	Polyvinyl Acetate
Phenolic	Styrene Butadiene Latexes	Polyvinyl Alcohol
LD Polyethylene	Other Styrene-based	Other Vinyl Resins
HD Polyethylene	Latexes	Thermoplastic Polyester

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MONTHLY STATISTICAL REPORT
THE SOCIETY OF THE PLASTICS INDUSTRY, INC.
(In thousands of pounds, dry weight basis)

THERMOSETTING RESINS

DECEMBER 1980

RESIN KIND & USE	SALES & CAPTIVE USE						PRODUCTION					
	DECEMBER			YEAR-TO-DATE			DECEMBER			YEAR-TO-DATE		
	1980	1979	% Change	1980	1979	% Change	1980	1979	% Change	1980	1979	% Change
EPOXY (UNMODIFIED) RESINS, TOTAL	30,709	25,639	+ 19.8	318,756R	331,970	– 4.0	26,491	24,829	+ 6.7	315,039R	361,077	– 12.8
Total Exports	3,732	3,496	+ 6.8	35,547	35,730	– 0.5						
Total Domestic	26,977	22,143	+ 12.8	283,209R	296,240	– 4.4						
Bonding & Adhesives	1,931	1,431	+ 34.9	17,742R	17,454	+ 1.7						
Flooring, Paving & Exposed Aggregate	1,886	1,481	+ 27.3	19,231R	19,583	– 1.8						
Protective Coatings	13,417	9,648	+ 39.1	137,308R	146,137	– 6.0						
Fiber Reinforced Laminates & Composites	5,164	4,785	+ 7.9	62,690R	60,268	+ 4.0						
Tooling, Casting & Molding Resins	2,749	2,417	+ 13.7	25,664R	30,940	– 17.1						
All Other Uses	1,830	2,381	– 23.1	20,574R	21,858	– 5.9						
POLYESTER (UNSATURATED) RESINS, TOTAL	75,749	76,020	– 0.4	921,169R	1,151,581	– 20.0	76,524	78,733	– 2.8	925,947R	1,147,174	– 19.3
General Purpose Resins							66,503	68,719	– 3.2	805,583R	1,010,750	– 20.3
Fire Retardant Resins							2,757	2,550	+ 8.1	28,739	32,035	– 10.3
Chemical Resistant Resins							7,264	7,464	– 2.7	91,625R	104,389	– 12.2
Isophthalic Resins							3,630	4,917	– 22.1	52,437R	63,158	– 17.0
All Other Resins							3,434	2,547	+ 34.8	39,188R	41,231	– 5.0
Total Exports	903	841	+ 7.4	11,254	14,258	– 21.1						
Total Domestic	74,846	75,179	– 0.4	909,915R	1,137,061	– 20.0						
Reinforced Plastics, Total	59,069	58,428	+ 1.1	709,229R	905,949	– 21.7						
Non-Reinforced Plastics, Total	15,777	16,751	– 5.8	200,686R	231,112	– 13.2						
LOW-DENSITY POLYETHYLENE 0.940 & BELOW, TOTAL	719,992	666,312	+ 8.1	7,467,985R	7,814,845	– 4.4	675,113	650,391	+ 3.8	7,290,727R	7,793,223	– 6.4
Total Exports	109,576	65,000	+ 68.6	1,147,442R	897,575	+ 27.8						
Total Domestic	610,416	65,000	+ 68.6	1,147,442R	897,575	+ 27.8						
Film (12 Mils & Below)	610,416	601,312	+ 1.5	6,320,023R	6,917,270	– 8.6						
Sheet (Over 12 Mils)	392,242	383,360	+ 2.3	4,003,749	4,363,250	– 8.2						
Injection Molding	921	1,930	– 52.3	18,176	25,825	– 29.6						
Wire & Cable	46,555	57,100	– 18.5	519,294R	649,975	– 20.1						
Extrusion Coating	20,042	34,572	– 42.0	335,403	424,139	– 20.9						
Blow Molding	44,772	41,001	+ 9.2	517,406R	539,098	– 4.0						
Pipe & Conduit	5,129	4,786	+ 7.2	65,453R	59,524	+ 10.0						
Other Extruded Products	2,660	2,293	+ 16.0	21,768R	32,718	– 33.5						
All Other Uses	4,244	5,140	– 17.4	56,018R	79,614	– 29.6						
HIGH-DENSITY POLYETHYLENE ABOVE 0.940, TOTAL	93,851	71,130	+ 31.9	782,756R	743,127	+ 5.3						
Total Exports	413,377	394,243	+ 4.9	4,393,038R	4,893,243	– 10.2	407,174	419,864	– 3.0	4,405,021	5,009,839	– 12.1
Total Domestic	61,114	54,188	+ 12.8	526,438R	608,654	– 13.5						
Film (12 Mils & Below)	352,263	340,055	+ 3.6	3,866,600	4,284,589	– 9.8						
Sheet (Over 12 Mils)	21,622	14,714	+ 46.9	201,086	212,399	– 5.3						
Injection Molding	7,921	4,541	+ 74.4	54,937	65,520	– 16.2						
Wire & Cable	89,601	84,541	+ 6.0	937,964	1,073,724	– 12.6						
Extrusion Coating	6,285	7,074	– 11.2	105,555	125,921	– 16.2						
Blow Molding	3,213	2,038	+ 57.7	27,565	30,242	– 8.9						
Pipe & Conduit	138,168	139,521	– 1.0	1,573,140	1,724,076	– 8.8						
Other Extruded Products	30,468	25,135	+ 21.2	368,352	400,395	– 8.0						
All Other Uses	1,703	2,120	– 19.7	24,250	18,931	+ 28.1						
	53,282	60,371	– 11.7	573,751	633,381	– 9.4						

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